USAAEFA PROJECT NO. 76-07







# ARMY PRELIMINARY EVALUATION IMPROVED MAIN ROTOR BLADE INSTALLED ON A YAH-1R HELICOPTER

FINAL REPORT

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UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The United States Army Aviation Engineering Flight Activity conducted an Army Preliminary Evaluation of a YAH-1R helicopter, SN 70-16936, with the Kaman improved main rotor blade, designated K-747, installed. The tests were conducted to determine suitability for future Army testing and any performance differences with the K-747 rotor installed. The main rotor blade includes an advanced design airfoil, a tapered tip planform, composite material construction, and a multicell,



mt

20. Abstract

ballistically tolerant spar. The helicopter was tested from 26 November through 6 December 1976 at the Kaman Aerospace Corporation facility in Bloomfield, Connecticut. During the test, eleven flights were flown for a total of 13.0 flight hours, 9.9 of which were productive. Test results indicate that the YAH-1R with the K-747 rotor has an increase in hover performance over the YAH-1S. A level flight performance improvement above 60 knots true airspeed became more pronounced as weight and altitude were increased. Climb and autorotational descent performance, static and dynamic stability, and mission maneuvering characteristics remain essentially unchanged from previous AH-1 helicopters. Qualitatively, there was a decrease in noise levels with the K-747 rotor. Simultaneous stability and control augmentation system (SCAS) hardovers occurred in all axes on five occasions during this evaluation. The lack of SCAS troubleshooting procedures in AH-1 organizational maintenance publications impeded timely correction of the problem and precluded completing all planned tests within the calendar time constraints. No deficiencies were found, and a total of eight shortcomings were noted, none of which were associated with the K-747 rotor, and most have been previously reported on AH-1 helicopters.

DEPARTMENT OF THE ARMY
HQ, US ARMY AVIATION RESEARCH AND DEVELOPMENT COMMAND
P O BOX 209, ST. LOUIS, MO 63166

25 MAY 1977

DRDAV-EQ

SUBJECT: USAAEFA Project No. 76-07 Army Preliminary Evaluation, Improved Main Rotor Blade Installed on a YAH-1R Helicopter June 1977

SEE DISTRIBUTION

1. The purpose of this letter is to present the Directorate for Development and Engineering position on the subject report.

2. Specific comments by paragraph are:

a. Abstract, 11th sentence - While the test results did indicate that the YAH-1R with K-747 rotor blades has an increase in hover performance over the AH-1S, the magnitude of the tests conducted were not sufficient to define the extent of the improvement.

b. Paragraph 42 - Agree with the general conclusions of this report.

c. Paragraph 43 - The five shortcomings identified in this paragraph have been described in previous AEFA reports. These shortcomings have been addressed and no corrective action is deemed necessary except for correction of inadequate low airspeed cues. This shortcoming will be corrected on the Modernized AH-1S.

d. Paragraph 44 - Correction of cited shortcomings is addressed in paragraph 2c above.

e. Paragraph 45 - The Marconi Avionics Air Data System will be installed in all Modernized AH-1S helicopters.

f. Paragraph 46 - Sufficient SCAS troubleshooting procedures have been developed and are contained in TM 55-1520-236-23.

g. Paragraph 47 - Increasing the published sideward velocity limit above 35 knots has been considered but the requirement has not been substantiated.

h. Paragraph 48 a, b, - The areas listed are being considered for further test projects.

25 MAY 1979

DRDAV-EQ

SUBJECT: USAAEFA Project No. 76-07 Army Preliminary Evaluation, Improved Main Rotor Blade Installed on a YAH-1R Helicopter, June 1977

i. Paragraph 58c - Contractor development test data has been thoroughly reviewed and no adverse characteristics or trends have been noted.

k. Appendix A Reference 15 - Kaman Report No. should be T-705 not T-70R as listed.

FOR THE COMMANDER:

WALTER A. RATCLIFF
Colonel, GS
Director of Development
and Engineering

# TABLE OF CONTENTS

# INTRODUCTION

## BACKGROUND

1. The United States Army Aviation Systems Command (AVSCOM) since redesignated the Army Aviation Research and Development Command (AVRADCOM) awarded a development contract to Kaman Aerospace Corporation (KAC) in May 1975 to design, fabricate, and test an improved main rotor blade, designated K-747, for the AH-1 series helicopter. The design objectives of the program were to provide improved hover performance, reduced ballistic vulnerability, and improved reliability and maintainability characteristics. In August 1976, AVSCOM directed the United States Army Aviation Engineering Flight Activity (USAAEFA) to conduct an Army Preliminary Evaluation (APE) of the YAH-1R helicopter with the K-747 rotor installed (refs 1 and 2, app A). A formal test plan for the APE was published in November 1976 (ref 3).

## TEST OBJECTIVES

2. The objectives of the APE were as follows:

a. Determine suitability of the aircraft incorporating the K-747 rotor for future Army testing.

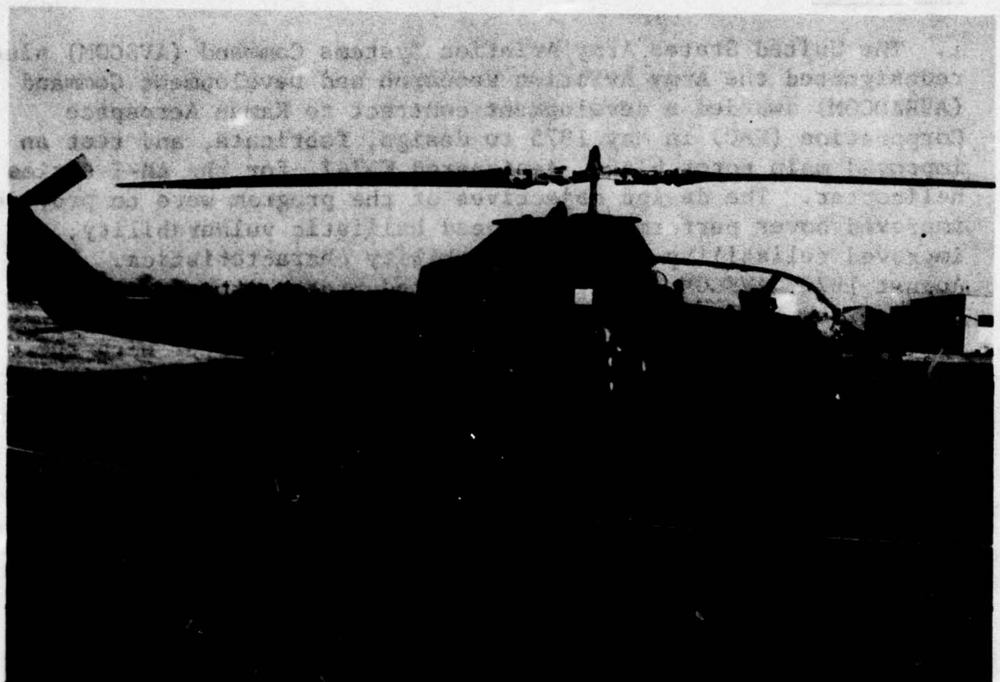
b. Determine the effects of the K-747 rotor on YAH-1R performance.

c. Detect and allow for early correction of any deficiencies or shortcomings.

## DESCRIPTION

3. The YAH-1R, shown in photo A, is a 10,000-pound maximum gross weight attack helicopter derived from the AH-1G HueyCobra. A detailed description of the AH-1G helicopter and its armament systems is included in the operator's manual (ref 4, app A). The increased gross weight capability, maneuverability, and agility are provided by incorporating uprated drive system components from the AH-1J SeaCobra, a Bell Helicopter Textron Model 212 tail rotor, and the Lycoming T53-L-703 engine, with an uninstalled thermal rating of 1800 shaft horsepower (shp), transmission limited to 1290 shp. Four wing-mounted external stores locations are

provided two on each side of the fuselage. The test aircraft had wings from an AH-1Q installed to allow mounting of TOW missile launchers. The aircraft is configured with an integral chin turret that is aimed by the gunner.



4. The K-747 rotor incorporates an advanced design airfoil with a tapered tip planform constructed of composite material with a multicell, ballistically tolerant spar. The blades are designed to be individually interchangeable. The K-747 rotor is designed to replace the standard AH-1 main rotor, designated the B-540, without modification other than pitch-link assembly adjustment. A detailed description of the Model 212 tail rotor is contained in USAASTA Final Report No. 72-30 (ref 5, app A). Appendix B provides a detailed description and photos of the test helicopter (SN 70-15936) and the K-747 rotor.

## TEST SCOPE

5. The evaluation was conducted on the prototype YAH-1R at the KAC facility in Bloomfield, Connecticut (164-foot field elevation). Eleven flights totaling 9.9 productive flight hours were conducted

between 26 November and 6 December 1976. The contractor installed, calibrated, and maintained all instrumentation, and was responsible for test aircraft maintenance and logistical support during the tests. Flight restrictions and operating limitations were established by the AH-1S operator's manual (ref 6, app A) as modified by the safety-of-flight release (ref 7) issued by AVSCOM. Stringent calendar limitations, coupled with adverse weather conditions and stability and control augmentation system (SCAS) malfunctions, prevented completion of all phases of testing as specified in the test plan. The evaluation was conducted with SCAS ON. Aircraft configurations tested included 8-TOW (two dual-TOW launchers on each outboard wing store location); Hog-TOW (8-TOW configuration with an XM200 (one XM200 rocket launcher mounted on each inboard and outboard wing station). Flight test conditions are shown in table 1.

## TEST METHODOLOGY

6. The engineering flight test techniques described in references 8 through 10, appendix A, were used in conducting performance and handling qualities tests. The data acquisition system utilized pulse code modulation (PCM) telemetered to and recorded at the contractor facility. Hand-recorded cockpit data were taken from calibrated cockpit indicators to facilitate correlation of the telemetered data. A detailed listing of the test instrumentation is contained in appendix C. Data reduction techniques are further described in appendix D. Data reduction was accomplished using the KAC computer facilities. A Handling Qualities Rating Scale (HQRS), shown in appendix D, was used to augment pilot comments relative to handling qualities.

Table 1. Flight Test Conditions.

| Type of Test | Gross Weight (lb) | Longitudinal Center of Gravity Fuselage Station | Density Altitude (ft) | Airspeed (kt) | External Stores Configuration[1] | Remarks[2] |
|---|---|---|---|---|---|---|
| Sideward flight | 9540 | 195.2 mid | -3320 | 17 left to 22 right | 8-TOW | --- |
| Static longitudinal stability | 9830 | 201.0 aft | 5090 | 37 and 117[3] | Hog | --- |
| Static lateral-directional stability | 9690 | 201.0 aft | 4910 | 36 and 118[3] | Hog | Varying sideslip |
| Maneuvering stability | 9880 | 201.1 aft | 5380 | 57[3] | Hog | Climb trim |
|  | 9660 | 201.0 aft | 5550 | 117[3] | Hog | Level trim |
| Controllability | 9950 | 194.4 mid | -3230 | Less than 10[3] | Hog-TOW | 50 ft |
| Mission maneuvers | 9500 | 201.0 aft | -3300 | Zero to 100[3] | Hog | Ball centered |

[1]Configuration definitions given in paragraph 5 and shown in appendix B.
[2]Unless otherwise noted, tests were flown using K-747 rotor; rotor speed ($N_R$) of 325 rpm; zero sideslip; true airspeed.
[3]Calibrated airspeed.

# RESULTS AND DISCUSSION

## GENERAL

7. An APE of the YAH-1R helicopter with the K-747 rotor installed was performed to determine the effect of the K-747 rotor on YAH-1R performance and handling qualities. A significant weight and balance computation error was discovered subsequent to these tests. The flight loadings of all contractor development and demonstration flights were also based on this erroneous weight and balance information. The data obtained during the development test should be critically reviewed for any adverse characteristics or trends with forward cg movement. Two flights were flown 1 inch aft of the aft cg limit because of the error. No adverse handling qualities associated with the aft cg were observed. Limited hover, level flight, and climb performance tests were conducted. The data are not presented for the following reason: the best available information at the time of the evaluation indicated that engine power could best be obtained using the relationship between torque pressure and engine torque used in reference 8; information received subsequent to the completion of the report indicated that the test engine differed significantly in the relationship between torque pressure and engine torque from that used in the analysis. Rather than recalculate the performance data, it was considered cost and time effective to eliminate the data from the report. Similar and more complete performance data on the IMRB are presented in the *Airworthiness and Flight Characteristics* report (project no. 76-08). Maneuvering, static, dynamic stability, and mission maneuvering characteristics remained essentially unchanged from standard AH-1 helicopters. Qualitatively, there was a decrease in noise levels with the K-747 rotor. Simultaneous SCAS hardovers occurred in all axes on five occasions during this evaluation. The lack of SCAS troubleshooting procedures in AH-1 organizational maintenance publications hindered timely correction of the problem. No deficiencies were found and a total of five shortcomings were noted, none of which were associated with the K-747 rotor, and most were previously noted on AH-1 helicopters.

## HANDLING QUALITIES

### Control Positions in Trimmed Forward Flight

8. Control positions in trimmed forward flight were determined

during level flight performance tests at the conditions listed in table 1. The helicopter was trimmed in steady-heading zero sideslip flight at the desired airspeed with control forces trimmed to zero. Data were recorded at each stabilized airspeed. Test results are presented in figures 9 and 10, appendix E.

9. The variation of longitudinal control position with airspeed was essentially linear, with increased forward cyclic required with increased airspeed. The variation of lateral control position with airspeed was nonlinear; cyclic position moved right with increasing airspeed to approximately 75 KCAS and then moved to the left as airspeed increased to 132 KCAS. The reversal (0.5 inch) was not discernible to the pilot. The variation of directional control position with airspeed was similar to that of the lateral cyclic control position. Within the scope of this test, control position characteristics in trimmed forward flight of the YAH-1R with K-747 rotor installed are not significantly changed from the basic aircraft and met the applicable requirements of military specification MIL-H-8501A (ref 14, app A).

Control Positions in Sideward Flight

10. The handling qualities during sideward flight of the YAH-1R helicopter with K-747 rotor installed were evaluated at the conditions shown in table 1. The test aircraft was flown IGE at an approximate skid height of 10 feet. A pace vehicle with calibrated speedometer was used as a speed reference. Winds during this test series were less than 5 knots. The aircraft was stabilized at an airspeed, and data were recorded. Test results are presented in figure 11, appendix E.

11. The variation of control positions with true airspeed in sideward flight showed varying gradients in all axes which presented no control problems. There were no objectionable control position changes in sideward flight. Within the limited scope of the test, the handling qualities of the YAH-1R with K-747 rotor installed in sideward flight simulating crosswind hovering are satisfactory and are not significantly changed from the standard aircraft.

12. During this evaluation, sideward flight only to 17 KTAS left and 22 KTAS right was flown because of failure in all axes of the SCAS after recovering from the 17-KTAS left sideward data point (para 49). Calendar time constraints did not allow completion of the low-speed flight characteristics tests after the SCAS failure was corrected.

## Static Longitudinal Stability

13. Collective-fixed static longitudinal stability was evaluated at the conditions shown in table 1. The helicopter was trimmed in steady-heading zero sideslip flight at the desired trim airspeed. Then, with the collective stick held fixed, the helicopter was stabilized at incremental airspeeds greater than and less than the trim airspeed. Data were recorded at each stabilized airspeed. Test results are presented in figures 12 and 13, appendix E.

14. At a trim airspeed of 36 KCAS, the variation in longitudinal control position with airspeed was stable and the stick position gradient was shallow (0.6 inch of forward control travel from 21 to 51 KCAS). The variation of pitch attitude with airspeed was essentially zero. The neutral character of the pitch attitude gradient and shallow longitudinal control position gradient made pitch attitude and control position impossible to use as airspeed cues in low-speed flight (21 to 51 KCAS). However, this lack of pitch attitude change and small control change was helpful in hovering and low-speed flight in winds. Wind gusts will not upset the hover pitch attitude; thus, minimal pilot compensation will be required to maintain hover position (HQRS 3).

15. In high-speed cruise flight (94 to 139 KCAS), static longitudinal stability, as indicated by the variation of longitudinal cyclic position with airspeed, was essentially neutral. The variation of pitch attitude with airspeed was minimal (4.0-degree nose-down pitch attitude change from 94 to 139 KCAS), but due to the excellent cockpit references, small pitch attitude changes were easily detected and provided suitable cues to airspeed changes. Minimal pilot effort was required to maintain airspeed during high-speed cruise (HQRS 3). Within the scope of this evaluation, the static longitudinal stability of the YAH-1R helicopter with K-747 rotor installed is not significantly changed from the standard aircraft, met the requirements of MIL-H-8501A, and is satisfactory.

## Static Lateral-Directional Stability

16. Static lateral-directional stability characteristics were determined at the conditions shown in table 1. The aircraft was initially trimmed at zero sideslip in level flight at the desired airspeed. With collective control fixed and airspeed held constant, the aircraft was stabilized at incremental sideslip angles from zero to the limit of the sideslip envelope, both left and right. Test results are presented in figures 14 and 15, appendix E.

17. Static directional stability, as indicated by the variation of directional control position with sideslip, was positive up to the limit of the sideslip envelope. Effective dihedral, as indicated by the variation of lateral cyclic control position with sideslip, was positive. The weak side-force characteristics during low-speed flight, as indicated by the variation of bank angle with sideslip, were determined to be essentially the same as the basic YAH-1R (ref 9, app A). The weak side-force characteristics resulted in extensive pilot effort to maintain low-speed flight (HQRS 6). *Weak side-force characteristics during low-speed* forward flight are a shortcoming.

18. Firing stowed or fixed weapons required known sideslip to obtain first-round hits. Weak side-force characteristics made this an extremely difficult task. An airspeed system capable of giving accurate velocity information, both magnitude and direction (sideslip), throughout the rearward, sideward, and forward airspeed envelopes should be installed in all AH-1 helicopters. Within the scope of this test, the static lateral-directional stability characteristics of the YAH-1R with K-747 rotor installed are not significantly changed from the standard aircraft.

Maneuvering Stability

19. Maneuvering stability characteristics were evaluated at the conditions shown in table 1 with SCAS ON. Trim conditions were 117 KCAS at maximum continuous power (MCP) and zero sideslip in level flight, and 57 KCAS in a zero sideslip maximum power climb. The variation of longitudinal and lateral cyclic and pedal control positions with cg normal acceleration was determined by stabilizing the aircraft in constant airspeed zero sideslip turns at incremental roll attitudes left and right. The collective control remained fixed during the maneuver, and power and rotor speed varied because of the pitch cone coupling and altitude variation during the turn. The quantitative results of the maneuvering stability evaluation are presented in figures 16 and 17, appendix E.

20. At 57 KCAS and near maximum power, the aircraft was in a climbing spiral with normal acceleration to approximately 1.2g, and in a descending spiral at normal accelerations in excess of 1.2g, as shown in figure 17, appendix E. The longitudinal control position variation with normal load factor showed a sharp change in slope at 1.30g. The gradient decreased but remained positive and essentially linear above 1.30g. The aircraft was easy to control during these maneuvering turns and minimal pilot compensation was required to achieve satisfactory performance in

simulated rapid returns to a target at 57 KCAS with maximum power (HQRS 3). As aircraft normal acceleration approached 1.5g, there was a noticeable increase in the 2-per-rotor-revolution (2/rev) vibration, which was not objectionable.

21. Figure 17, appendix E, shows maneuvering stability test results for the YAH-1R helicopter with K-747 rotor installed at 117 KCAS with MCP. Maneuvering stability under these conditions was positive below 1.5g; however, the stick position gradient became essentially neutral above 1.5g. The aircraft was very difficult to control precisely above 1.4g due to pitch oscillation. Although the aircraft did present control difficulty when the task was defined as precise airspeed control, the aircraft was responsive. The pilot could not prevent airspeed oscillations about the desired trim airspeed, but there was no tendency toward a divergence in pitch or roll. No divergent tendency was noted in symmetrical pull-ups to approximately 1.7g, the limit for this test. The neutral maneuvering stability above 1.5g at 117 KCAS is a shortcoming. This shortcoming was noted on an earlier APE (ref 9, app A). Tests should be conducted to investigate the maneuvering stability of the YAH-1R helicopter to the aircraft's full load factor capability at the more severe flight conditions of higher density altitude, heavier gross weight, and faster airspeed. Tests should include constant-power turns and symmetrical pull-ups.

22. During the maneuvering flight evaluation at 117 KCAS a 2/rev vertical vibration, which increased in intensity as normal load factor increased, was noted. A slight amount of cyclic control feedback was encountered at normal acceleration in excess of 1.5g. The cyclic control feedback did not materially affect the pilot's ability to obtain small increments of load factor.

23. Maneuvering stability tests revealed a longitudinal control position gradient change at approximately 1.30g at 57 KCAS and 1.5g at 117 KCAS. These levels of normal acceleration occurred at the pitch rate which resulted in full extension of the longitudinal SCAS actuator. The shift in maneuvering stability gradient probably reflects the difference in the artificially stabilized airframe and the basic airframe characteristics. Subsequent analysis of the data revealed that the longitudinal SCAS actuators fully extended at approximately 8 degrees per second pitch rate. The effective loss of longitudinal SCAS due to full actuator extension did not materially affect the maneuvering handling qualities at 57 KCAS; however, at 117 KCAS this effective loss of SCAS input degraded the maneuvering handling qualities, in that precise airspeed control required extensive pilot compensation during steeply banked diving turns (HQRS 6).

Within the scope of this test, the maneuvering stability characteristics of the YAH-1R helicopter with K-747 rotor installed are not significantly changed from the standard aircraft.

Controllability

24. Controllability characteristics were evaluated in IGE hover with SCAS ON at the conditions shown in table 1. The aircraft was trimmed in a stable hover attitude and control step inputs of varying sizes were applied to each axis, using a mechanical fixture to obtain the desired input size. The inputs were held until a maximum rate was established or until recovery was necessary. Test results are presented in figures 18 through 23, appendix E.

25. There were no objectionable delays in the development of angular rates in response to control displacements. Angular rates and accelerations developed in the proper direction within 0.2 second after the control displacement. Aircraft responses were essentially uncoupled except for right lateral cyclic control inputs. Responses from right lateral cyclic inputs resulted in right yaw coupling. This yaw coupling should cause no controllability problems in operational use.

26. Pitch attitude change in 1 second, maximum pitch acceleration, and maximum pitch rate were essentially linear functions of the longitudinal input size. The time to maximum pitch acceleration was 0.25 second. The time to maximum pitch rate was approximately 0.9 second and was independent of the input size within the accuracy of time determination.

27. Lateral step inputs produced responses which were linear with input size. Time to maximum roll acceleration was 0.2 second and time to maximum roll rate was approximately 0.9 second.

28. Yaw responses to step pedal control inputs were essentially linear for inputs up to 1.0 inch left and right. In comparing the test results of this evaluation with those of an earlier test, the only significant difference was in the time required to achieve a given yaw displacement for comparable yaw control inputs. This difference can be directly attributed to an instrumentation lag in heading output. A comparison of the transient tail rotor torque recorded during controllability tests and that resulting from the slower inputs during hover turn arrestments indicates that the maximum transient torques are primarily a function of the magnitude of the input and are relatively independent of the rate of input for input times of 0.1 to 1.0 second. An oscillation was

noted in both tail rotor torque and main rotor torque as a result of pedal inputs. This lightly damped torsional oscillation appears to contribute to the high peak tail rotor transient torque. A similar torsional oscillation has been noted in other AH-1 aircraft. Within the scope of this test, the controllability characteristics of the YAH-1R with K-747 rotor installed are not significantly changed from the standard aircraft.

Mission Maneuvering Characteristics

Lateral Acceleration/Deceleration/Low-Speed Flight:

29. Lateral acceleration handling qualities were evaluated at the conditions shown in table 1. The aircraft was stabilized at the desired hover height and then lateral acceleration was initiated by simultaneously applying lateral cyclic and increasing collective pitch to achieve torque equivalent to MCP. Lateral control was used to maintain a constant height as the aircraft accelerated. Lateral control reversals were initiated at maximum sideward velocity by reducing collective pitch and executing a side flare maneuver while attempting to maintain altitude.

30. Lateral accelerations/decelerations were conducted IGE at a gross weight of 9500 pounds. Aircraft handling qualities during lateral acceleration/deceleration maneuvers were good. Qualitatively, acceleration to the left was greater than to the right, as shown with the YAH-1R helicopter (ref 9, app A). Heading was easy to maintain in either direction throughout the maneuver (HQRS 2).

31. The YAH-1R/S sideward velocity envelope was expanded to 50 knots (refs 8 and 10, app A), which enhanced the lateral agility of the aircraft. The safety-of-flight release for this test limited the aircraft to 35 knots in sideward flight. Consideration should be given to expanding the sideward velocity envelope of all AH-1 helicopters to further enhance their lateral agility.

32. Sideward velocities were very difficult to judge during lateral accelerations. Attack helicopter tactics required rapid lateral translations over the ground to minimize vulnerability to enemy weapons. The aircraft has a limit airspeed (35 knots in sideward flight) which cannot be observed or sensed accurately by the pilot. The lack of adequate airspeed cues in low-speed flight (para 28) does not allow the pilot to fully utilize nap-of-the-earth (NOE) navigational techniques which require a constant low airspeed for a specific time period to navigate between two points at a low altitude. The low altitude requires the pilot to direct his attention outside the cockpit to avoid striking obstacles.

In low-speed flight (21 to 51 KCAS), airspeed could increase 100 percent or decrease 50 percent and no discernible cues would indicate the airspeed change to the pilot. Maintaining an airspeed in the low-airspeed range (21 to 51 KCAS) requires extensive pilot compensation (HQRS 6). The lack of airspeed cues during low-speed flight is a shortcoming. An omnidirectional airspeed system should be installed to give the pilot an indication of the magnitude and direction of the airspeed vector. Such a system would allow the pilot to more fully utilize the sideward flight and NOE capability of the AH-1 helicopter.

33. A side flare maneuver was performed to decelerate the helicopter from the peak sideward velocities obtained during the lateral accelerations. With the lateral control reversal initiating a side flare, the aircraft began to climb. Collective control was lowered to maintain altitude, resulting in an engine/rotor overspeed tendency noted previously on the YAH-1R helicopter. The deceleration could be accomplished faster by allowing engine speed to increase to 6700 rpm and maintaining this engine speed by controlling rapidity of maneuver rather than "beeping" engine speed down. This reduced rotor speed control problems as velocity approached zero. Heading control was easily maintained throughout the maneuver (HQRS 2) and no control limits were reached.

Longitudinal Deceleration:

34. Handling qualities during longitudinal decelerations were evaluated at the conditions shown in table 1. The aircraft was stabilized at 100 knots indicated airspeed (KIAS) at a skid heig of 40 to 50 feet, power reduced, and aft longitudinal cyclic applied to reduce airspeed while maintaining altitude. Rotor speed control required extensive pilot compensation (HQRS 6). The tendency for engine overspeed resulting from poor engine/rotor dynamic characteristics is a shortcoming and should be corrected in future designs. Forward field of view is obstructed with the aircraft in a decelerating altitude, a shortcoming common to all AH-1 helicopters. The tendency to enter power settling at the termination of a rapid deceleration was previously reported on the YAH-1R helicopter and continues to exist. Power settling was avoided by decreasing the deceleration rate as the aircraft approached a hover.

Bob-Ups and Terrain Avoidance Maneuver:

35. The bob-up maneuver was accomplished by establishing an IGE hover and then conducting a maximum power vertical climb to an OGE hover, to simulate a climb above a masked position to engage

a target. A terrain avoidance maneuver was accomplished by establishing 100 KIAS in level flight, skid height of 40 to 50 feet, and then rapidly increasing altitude by 200 feet, using a cyclic climb and pushover to simulate obstacle clearance during contour flight. No handling qualities difficulties were encountered during these maneuvers (HQRS 2).

MISCELLANEOUS

Stability and Control Augmentation System Failures

36. During the conduct of this evaluation yaw oscillations occurred in all regimes of flight, but were more noticeable during stabilized performance data points. An example of these oscillations is presented in figure 24, appendix E. SCAS position instrumentation also indicated these oscillations. Following the installation of new SCAS channel control assemblies, SCAS failures occurred in all three axes simultaneously on five separate occasions. An example of the SCAS failures is presented in figure 25. Hardovers in all three SCAS channels occurred within 1 second. Productive testing ceased until the cause of the SCAS failures could be corrected. The organizational maintenance manuals for the AH-1 series helicopters do not contain troubleshooting guides for SCAS failures. A heat-sensitive roll SCAS channel control assembly was determined to have caused the hardovers. Published troubleshooting procedures for the SCAS would have saved many maintenance manhours and allowed an early solution to the SCAS failure problem. SCAS troubleshooting procedures should be established and published in organizational maintenance manuals.

Vibration

37. Vibration data were recorded on all flights at nine sensor locations on the aircraft. Examples of vibratory amplitudes at various main rotor blade harmonic frequencies are presented in figures 26 through 66, appendix E. No maneuvers were performed specifically to induce high vibrations.

38. The vibration characteristics of the YAH-1R with K-747 rotor installed demonstrated no significant change in the 2/rev main rotor harmonic frequency measured at the cg and pilot station. An approximate 50-percent reduction in the 2/rev frequency vibration was measured at the copilot station, as shown in figure 29, appendix E. A reduction of the 8/rev main rotor harmonic frequency from that with the B-540 rotor system was measured throughout the airspeed range tested, as shown in figures 26

through 32. An increase in the 6/rev frequency with the K-747 rotor over the B-540 rotor occurred in the 70 to 100-KIAS airspeed range. These vibration characteristic differences were noticeable to the pilot and copilot, but were not objectionable and did not impair performance or comfort. The vibration levels did not exceed the requirements of MIL-H-8501A.

## Engine Characteristics

39. Throughout this evaluation, fluctuations in power turbine speed ($N_2$) and engine torque occurred with magnitudes of ±100 rpm and ±2 psi, respectively. These fluctuations were most noticeable during tests requiring constant power and airspeed. These fluctuations compromised the quality of the performance data and required extensive pilot compensation to stabilize the aircraft on a test point during the performance testing. Previous T53 series engines have displayed power train oscillations not unlike those experienced during this evaluation. Investigations of the power train oscillations with the T53-L-703 engine should be conducted to determine the cause, conditions that might increase severity, and any structural implications.

## Noise

40. A qualitative noise evaluation of both the K-747 and B-540 rotors was made throughout the conduct of these tests. Both cockpit and ground noise levels were observed. The K-747 rotor demonstrated a reduction of the 2/rev "blade slap" from that of the B-540 rotor in all flight regimes. A quantitative noise evaluation of the K-747 rotor installed on an AH-1 is planned for future testing.

## Weight and Balance

41. A significant weight and balance error (para 13, app B) was discovered after the aircraft was delivered to Edwards Air Force Base, California. The flight loadings of all contractor development and demonstration flights were also based on this erroneous weight and balance information. All testing was conducted at a cg of 1.0 to 2.5 inches aft of the desired location. The data obtained during the development test should be critically reviewed for any adverse characteristics or trends with forward cg movement, since tests have not been conducted at the forward cg limits. Two flights were flown 1 inch aft of the aft cg limit because of the error. No adverse handing qualities associated with the aft cg were observed.

# CONCLUSIONS

## GENERAL

42. Within the limited scope of this evaluation, the YAH-1R helicopter with K-747 rotor installed is suitable for future Army testing to the limits described in reference 7, appendix A, except that forward cg should be limited to that demonstrated. The following conclusions relative to the Kaman K-747 rotor installed on the YAH-1R helicopter have been made:

a. YAH-1R stability and control characteristics investigated were not significantly changed by installation of the K-747 rotor (paras 9, 11, 15, 18, 23, and 28).

b. Qualitatively, the K-747 rotor was quieter than the B-540 rotor (para 40).

c. The vibration characteristics of the YAH-1R with K-747 rotor installed were different from the B-540 rotor, but not objectionable to the pilot and copilot and did not impair performance or comfort (para 38).

d. No deficiencies and five shortcomings were found, none of which were associated with the K-747 rotor (para 7).

## SHORTCOMINGS

43. The shortcomings listed below were identified during these tests. Most have been previously identified on the AH-1 series helicopter, are listed in the order of decreasing importance.

a. Adequate airspeeds cues did not exist during low-speed flight (para 32).

b. Weak side-force characteristics required extensive pilot effort during low-speed forward flight (para 17).

c. Maneuvering stability became neutral above 1.5g at 117 KCAS (para 21).

d. There existed a tendency for rotor/engine overspeed during constant altitude decelerations (para 34).

e. Forward field of view is obstructed with the aircraft in a decelerating attitude (para 34).

# RECOMMENDATIONS

44. Shortcomings should be corrected on the production AH-1S.

45. An omnidirectional airspeed system capable of giving accurate magnitude and direction of relative airspeed over the rearward, sideward, and forward flight envelopes should be installed on the production AH-1S (paras 18 and 32).

46. AH-1 SCAS troubleshooting procedures should be developed and published in the appropriate maintenance manuals (para 36).

47. The sideward velocity limits of all AH-1 helicopters should be expanded to enhance their lateral agility (para 31).

48. The following areas should be further investigated during future tests and studies.

a. Investigate the power train oscillations with the T53-L-703 engine to determine the cause, conditions that might increase severity, and any structural implications (para 39).

b. Investigate maneuvering stability to the full load factor capability of the AH-1 with K-747 rotor installed over a complete airspeed, altitude, and gross weight range (para 21).

c. The data obtained during the contractor development test should be critically reviewed for any adverse characteristics or trends with forward cg movement (para 41).

# APPENDIX A. REFERENCES


1. Letter, AVSCOM, DRSAV-EQI, 17 August 1976, subject: Transmittal of Test Requests for the Army Preliminary Evaluation (APE) and Airworthiness and Flight Characteristics of the AH-1 Improved Main Rotor Blade (IMRB).

2. Letter, AVSCOM, DRSAV-EQI, 1 November 1976, subject: Army Preliminary Evaluation of AH-1R Equipped with Improved Main Rotor Blade.

3. Test Plan, USAAEFA, Project No. 76-07, *Army Preliminary Evaluation, Improved Main Rotor Blade Installed on a YAH-1R Helicopter*, November 1976.

4. Technical Manual, TM 55-1520-221-10, *Operator's Manual, Army Model AH-1G Helicopter*, 12 December 1975.

5. Final Report, US Army Aviation Systems Test Activity (USAASTA), Project No. 72-30, *Engineering Flight Test, AH-1G Helicopter with Model 212 Tail Rotor, Part I, Load Survey*, June 1973.

6. Technical Manual, TM 55-1520-234-10, *Operator's Manual, Army Model AH-1S Helicopter*, 1 May 1976.

7. Letter, AVSCOM, DRSAV-EQI, 18 November 1976, subject: Safety-of-Flight Release for an APE of AH-1R with IMRB Installed, Project No. 76-07.

8. Final Report, USAAEFA, Project No. 74-34, *Airworthiness and Flight Characteristics Evaluation, YAH-1S Improved Cobra Agility and Maneuverability Helicopter*, August 1975.

9. Final Report, USAAEFA, Project No. 74-33, *Army Preliminary Evaluation, YAH-1R Improved Cobra Agility and Maneuverability Helicopter*, May 1975.

10. Addendum Final Report, USAAEFA, Project No. 74-33-1, *Army Preliminary Evaluation, YAH-1R Improved Cobra Agility and Maneuverability Helicopter*, August 1975.

11. Final Report, USAAEFA, Project No. 73-01, *Helicopter Lift Margin and Low-Speed Performance Evaluation, NUH-1M Helicopter*, to be published.

12. Final Report, USAASTA, Project No. 66-06, *Engineering Flight Test, AH-1G Helicopter (HueyCobra), Phase D, Part II, Performance*, April 1970.

13. Final Report, USAASTA, Project No. 72-43, *Airworthiness and Flight Characteristics Evaluation, AH-1Q Helicopter*, July 1973.

14. Military Specification, MIL-H-8501A, *Helicopter Flying and Ground Handling Qualities; General Requirements For*, 7 September 1961, with Amendment 1, 3 April 1962.

15. Final Report, Kaman Aerospace Corporation, T-70R, *AH-1Q Improved Main Rotor Blade, Airworthiness and Flight Characteristics Evaluation, Hover Performance*, Alamosa, Colorado, 15 March 1977.

16. Final Report, USAASTA, Project No. 72-30, *Engineering Flight Test, AH-1G Helicopter with Model 212 Tail Rotor, Part II, Performance and Handling Qualities*, September 1973.

# APPENDIX B. AIRCRAFT DESCRIPTION

FUSELAGE

1. The YAH-1R fuselage is identical in outward appearance to the AH-1G helicopter with the exception of AH-1Q wings installed to accommodate the TOW weapon system. The aircraft differs in outward appearance from the YAH-1S, used in data comparison, in that the YAH-1S has a nose-mounted TOW sighting unit and a pylon-mounted pitot-static system, while the YAH-1R has an AH-1G nose and pitot-static system. The test aircraft was painted with low reflective paint except for the wings. Neither set of rotor blades tested had low reflective paint. Internal modifications to strengthen the fuselage structure to accept higher stresses due to increased gross weight, engine power, and tail rotor power included strengthened transmission mounts and associated structure and strengthened tail boom.

MAIN ROTOR BLADES

2. The Kaman improved main rotor blade configuration for the AH-1 helicopter is designated K-747. The K-747 rotor has a multicell filament-wound fiberglass spar, a Nomex core afterbody, and a Kevlar trailing edge spline, all inclosed by fiberglass skin. At the inboard end, cheek-plates carry blade loads to an aluminum adapter, which attaches the blade to the current AH-1 rotor hub by the hub pin.

3. The current AH-1 main rotor is designated the B-540. The K-747 rotor has the same diameter and essentially the same solidity as the current rotor, although the blade planform is changed. The blade twist is increased and advanced airfoil shapes are employed. The K-747 rotor dynamic characteristics were designed to match those of the B-540 rotor. A 55-pound brass tip weight, integral with the spar, provides rotor inertial characteristics similar to the B-540 rotor.

4. Over the constant chord section of the blade, the chord is 2.5 feet. This compares to 2.25 feet on the B-540 blade for the whole blade length. The outer 15 percent of the K-747 rotor blade is tapered in both thickness and planform. The tip planform taper is trapezoidal and results in a tip chord of 0.83 feet. The solidity of the rotor is 0.0625, compared to 0.065 for the current rotor.

5. The K-747 rotor blade airfoil shape is based on a family of advanced airfoils developed by Boeing Vertol. For the outer 15 percent of the blade (*ie*, from r/R = .85 (85 percent blade radius station)) out, the 8 percent-thick Boeing Vertol VR-8 airfoil is used; from r/R = .25 to r/R = .67, the 12 percent-thick Boeing Vertol VR-7 airfoil is used, with a linear transition between the 67 and 85 percent radius stations. From r/R = .25 station inboard, the blade is built-up gradually by cheek-plates. The leading edge becomes blunt and reaches a maximum thickness of 25 percent at the root end of the blade at r/R = .18. The current AH-1Q hub, which has its hub pin at r/R = .15, is retained. There is an attachment adapter fitting and drag brace between the pin and the root-end of the blade. Figure 1 presents a planform view and figure 2 a cross-section view of the K-747 rotor blade configuration.

## ENGINE

6. The T53-L-703 engine installed in the YAH-1R helicopter reflects a growth step from the T53-L-13B engine. The T53-L-703 engine is a turboshaft engine with a two-stage axial flow-free power turbine; a two-stage axial flow turbine driving a combination five-stage axial, two-stage centrifugal compressor having a nominal 8:1 compression ratio at the thermodynamic rating of 1800 shp and incorporating compressor interstage air bleed; variable inlet guide vanes; and external annular atomizing combustor. A 3.2105:1 reduction gear housed in the air inlet housing reduces power turbine speed to output shaft speed (nominally 6604 rpm output shaft/324 rpm rotor speed). The engine reduction gearbox is limited to 1175 foot-pounds (ft-lb) torque 1477 shp) for 30 minutes and 1110 ft-lb torque (1396 shp) for continuous usage. The engine achieves this power growth over the T53-L-13B engine through increased gas producer speed and increased operating temperatures made possible by improved air cooling of the first-stage turbine. New materials are employed in the second-stage gas producer and power turbines. A $T_7$ interstage turbine temperature sensor harness has been incorporated for measurement of interstage turbine temperature, giving a more accurate indication of engine internal temperature than the $T_9$ temperature (exhaust gas) sensed in the T53-L-13B engine.

## TRANSMISSION AND TAIL ROTOR DRIVE

7. An uprated transmission and tail rotor drive system is installed in the YAH-1R helicopter. These systems have the following limits:

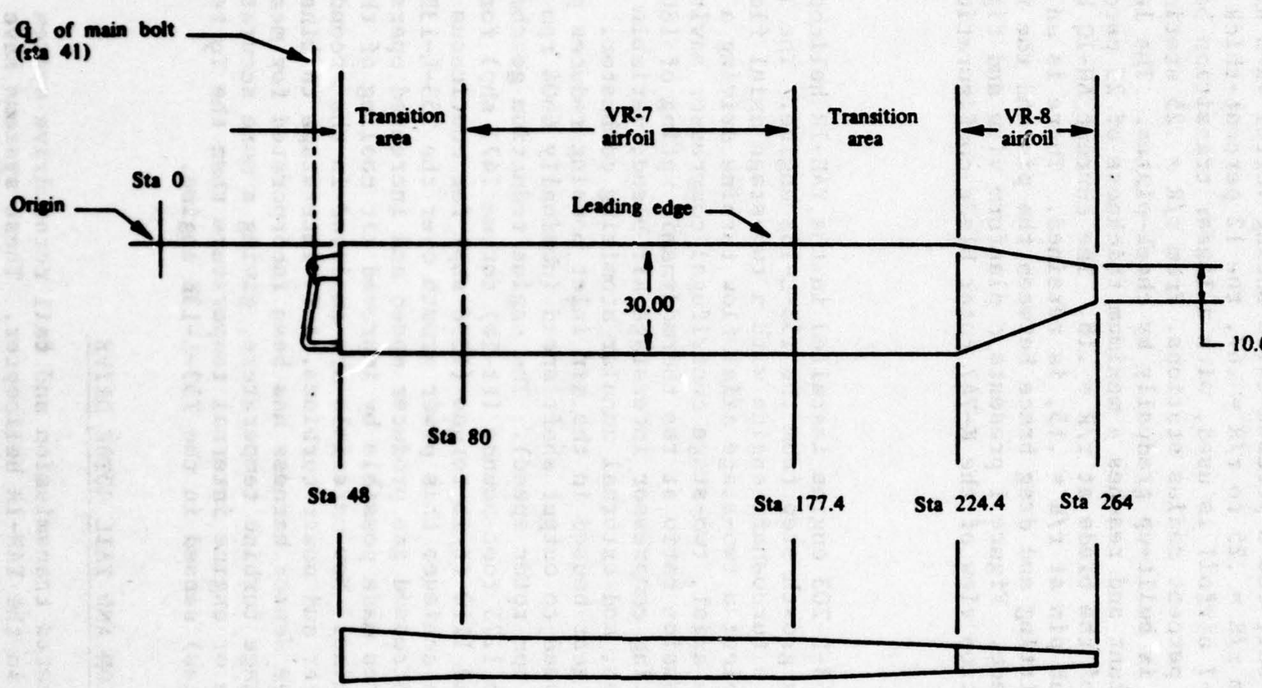



Figure 1. K-747 Rotor Blade Configuration.

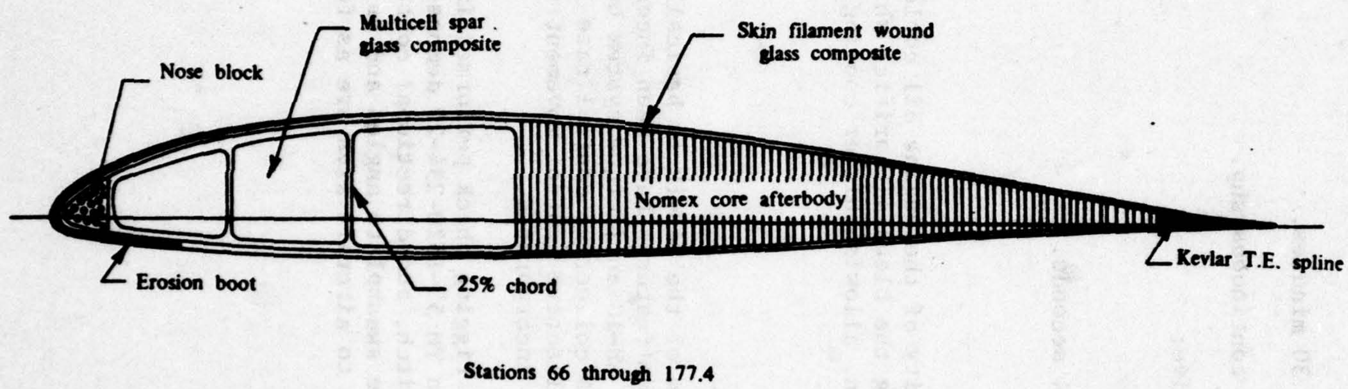



Figure 2. K-747 Rotor Blade Cross-Section Structural Arrangement

a. Transmission:

(1) 1290 shp for 30 minutes.

(2) 1134 maximum continuous shp.

b. Tail rotor drive:

(1) 187 shp MCP.

(2) 260 shp for 4 seconds.

ENGINE OIL COOLER

8. The cooling capacity of the engine oil cooler has been increased by enlarging the bleed air orifice which drives the turbine oil cooler fan, allowing higher cooling fan speed and cooling air mass flow.

CONTROL SYSTEM

9. The control system of the YAH-1R is basically the same as the AH-1G; however, two new features have been incorporated. The cable controls in the AH-1G antitorque system have been replaced by push-pull tubes. A collective control rate limiter, which limits the rate of collective control movement to full throw is 0.87 second, has been incorporated.

10. A flight control rigging check performed in accordance with procedures outlines in TM 55-1520-234-20 demonstrated that the cyclic, collective, pitch, and directional controls were within prescribed limits. The swashplate angles and tail rotor blade pitch angles relative to aircraft axes are as follows:

## SWASHPLATE ANGLES

| Cyclic Control Position | Lateral Angle | Longitudinal Angle |
|---|---|---|
| Neutral | 1.5 deg left down | 1 deg nose-up |
| Full forward | 5.0 deg right down | 10 deg nose-down |
| Full aft | 5.0 deg left down | 12.5 deg nose-up |
| Full right | 7.0 deg right down | 4.5 deg nose-up |
| Full left | 7.5 deg left down | 3.5 deg nose-down |

## TAIL ROTOR BLADE PITCH ANGLES

| Pedal Position | Blade Angle |
|---|---|
| Full left | 19.9 deg |
| Full right | -11.0 deg |

## PRINCIPAL DIMENSIONS

11. Principal dimensional and general data concerning the YAH-1R helicopter are as follows:

### Overall Dimensions

| | |
|---|---|
| Length, rotor turning | 52 ft, 11 in. |
| Width, rotor turning | 44 ft |
| Height, tail rotor vertical | 13 ft, 9.5 in. |
| Length, rotor removed | 45 ft, 2.2 in. |

| Main Rotor | K-747 | B-540 |
|---|---|---|
| Diameter | 44 ft | 44 ft |
| Disc area | 1520.5 $ft^2$ | 1520.5 $ft^2$ |
| Solidity | 0.0625 | 0.0651 |
| Number of blades | 2 | 2 |
| Blade chord | See fig. 1 | 2.25 ft, constant |
| Blade twist (linear) | -0.556 deg/ft | -0.455 deg/ft |
| Airfoil | See para 5 | 9.33 percent thickness, special symmetrical section |

**Tail Rotor**

| | |
|---|---|
| Diameter | 8 ft, 6 in. |
| Disc area | 56.75 $ft^2$ |
| Solidity | 0.1436 |
| Number of blades | 2 |
| Blade chord | 11.5 in., constant |
| Blade twist | 0.0 deg/ft |
| Airfoil | NACA 0018 at blade root, changing linearly to special cambered section of 8.27 percent of the tip |

**Fuselage**

| | |
|---|---|
| Length, rotor removed | 45 ft, 2.2 in. |
| Height: | |
| To tip of tail fin | 10 ft, 4 in. |
| Ground to top of mast | 11 ft, 7 in. |
| Ground to top of transmission fairing | 10 ft, 2 in. |
| Ground to bottom of chin turret | 1 ft, 2 in. |
| Width: | |
| *Fuselage only* | 3 ft |
| Wing span | 10 ft, 8.24 in. |
| Engine cowling | 3 ft, 6 in. |
| Skid gear tread | 7 ft, 4 in. |
| Elevator: | |
| Span | 6 ft, 2 in. |
| Area | 25.2 $ft^2$ |
| Airfoil | Inverted Clark Y |
| Vertical fin: | |
| Area | 18.5 $ft^2$ |
| Airfoil | Special cambered |
| Height | 5 ft, 6 in. |
| Wing: | |
| Span | 10 ft, 8.24 in. |
| Area | 27.8 $ft^2$ |
| Incidence | 14.0 deg |
| Airfoil (root) | NACA 0030 |
| Airfoil (tip) | NACA 0024 |

## WEIGHT AND BALANCE

12. The aircraft weight, longitudinal cg, and lateral cg were calculated from a weighing performed at the contractor's facility. The weighing was accomplished with all fuel drained and included instrumentation, empty chin turret, and empty wing stations. The weight was 6357 pounds with the longitudinal cg located at fuselage station (FS) 201.22 and the lateral cg located 0.18 inch right of the aircraft center line.

13. A significant weight and balance error was discovered after the aircraft was delivered to Edwards Air Force Base, California, for further testing. The flight loadings of all contractor development and demonstration flights were also based on this erroneous weight and balance information. The jack point locations used to calculate the cg from the weighing were erroneously taken from the AH-1G manual (TM 55-1520-221-10) (there are no AH-1R manuals; AH-1Q and AH-1S manuals were not available). The YAH-1R test aircraft was a modified AH-1G. One modification was the installation of prototype AH-1Q wings to allow loading of TOW missile launchers. This changed the wing jack point locations listed as FS 197.85 for the AH-1G/R wing to FS 200.35 for the AH-1Q/S. Actual measurement at Edwards using the forward jack point as a reference (there are no jig point locations in any AH-1 manuals) determined that the wing jack points were located at FS 200.45. A corrected weight and balance based on this value, resulted in a test aircraft empty weight of 6357 pounds, a longitudinal cg of 203.72, and a lateral cg of 0.18 right. All cg information in this report is based on this corrected weight and balance.

14. The external stores configurations, shown in photos 1, 2, and 3, were 8-TOW (two dual-TOW launchers with missile containers on each outboard wing station), heavy Hog (one XM200 rocket pod mounted on each inboard and outboard wing station), and Hog-TOW (8-TOW with one XM200 rocket pod on each inboard wing station). The TOW launchers and rocket pods were ballasted to achieve the desired takeoff weights.

15. Ballast weights were used at several longitudinal fuselage stations to achieve desired cg locations. Two cg locations were utilized during the test flights for evaluation. They were intended to be at the forward and aft limits of the cg envelope, respectively. Tables 1 and 2 show examples of intended and actual takeoff loadings to achieve the two cg locations.

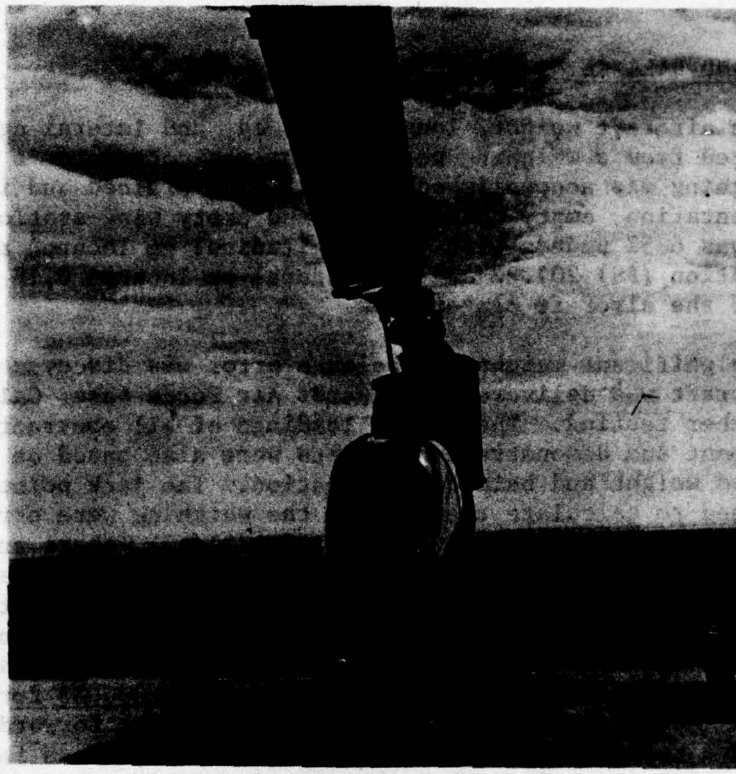


**Photo 1. Test Aircraft 8-TOW External Stores Configuration.**

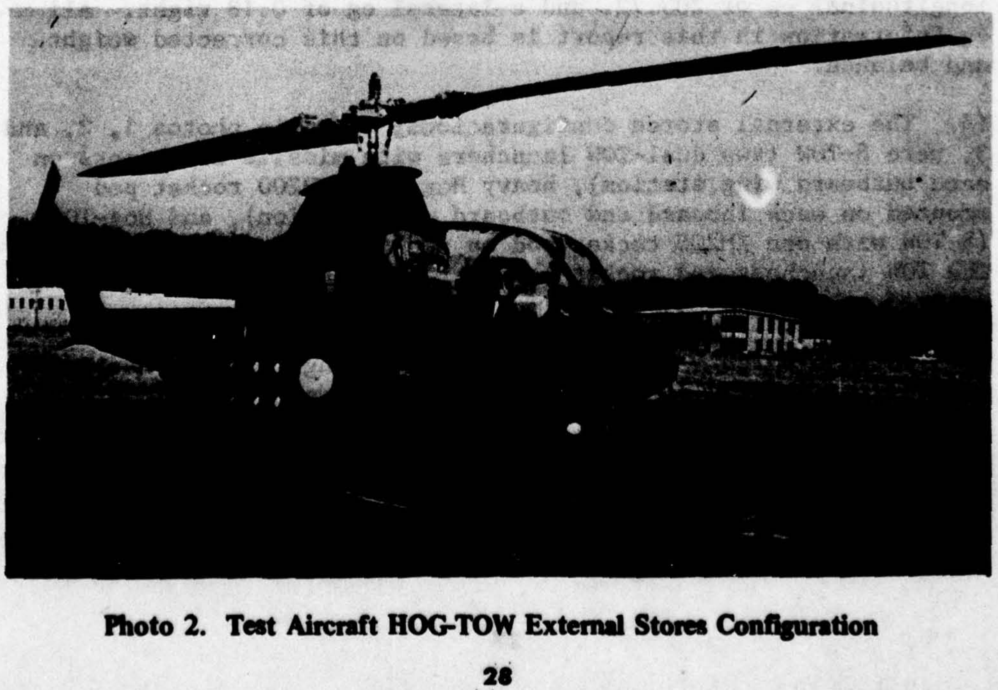


**Photo 2. Test Aircraft HOG-TOW External Stores Configuration**

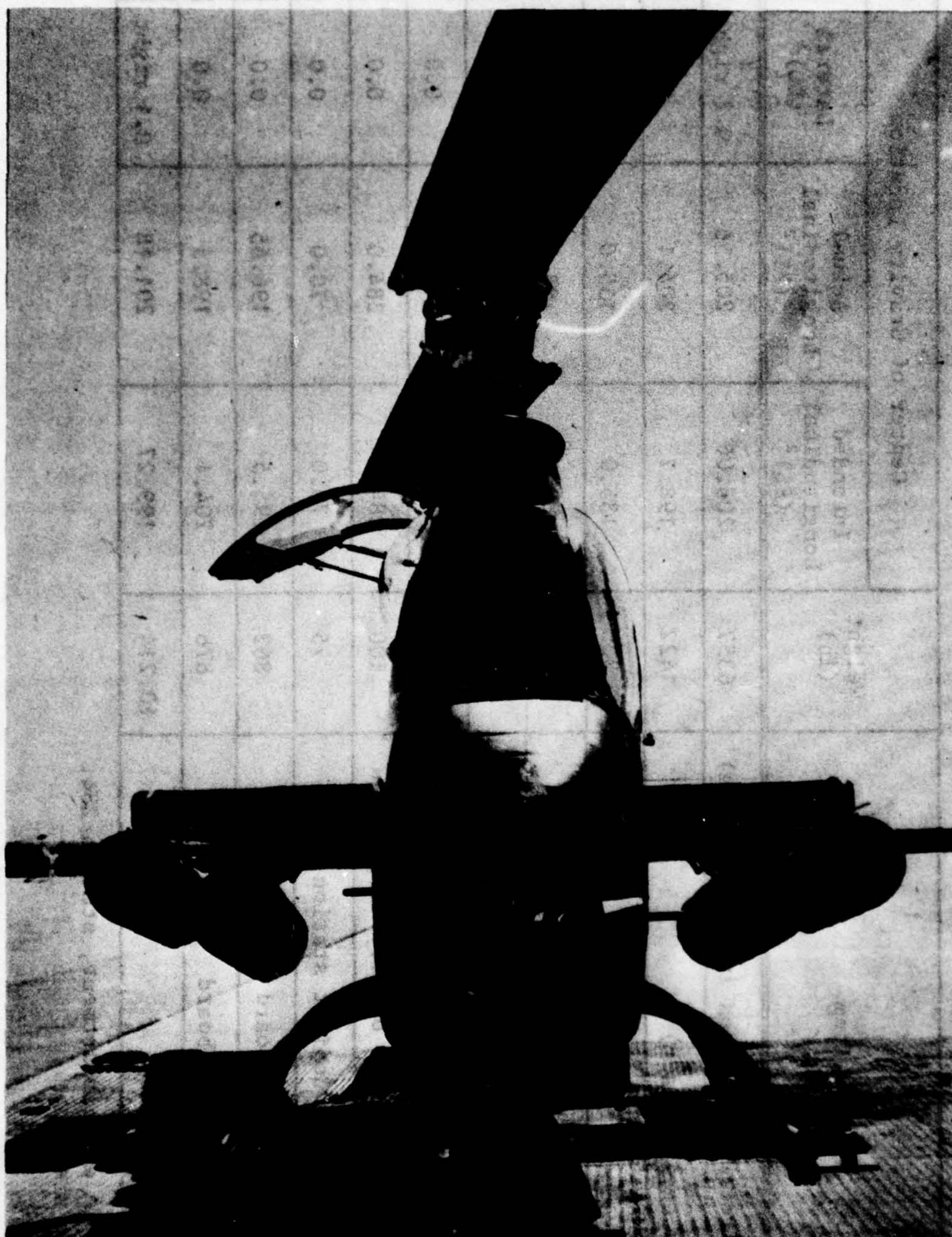


Photo 3. Test Aircraft HOG External Stores Configuration

Table 1. Aft Center of Gravity Loading Example.

| Item | | Weight (lb) | Center of Gravity Location | | |
|---|---|---|---|---|---|
| | | | Intended Longitudinal (FS)[2] | Actual Longitudinal (FS)[2] | Lateral (BL)[3] |
| Basic aircraft (includes instrumentation)[1] | | 6357 | 203.06 | 205.56 | 0.2 right |
| Fuel (at engine start) | | 1422 | 198.7 | 204.1 | 0.0 |
| Pilot | | 220 | 135.0 | 135.0 | 0.0 |
| Copilot | | 227 | 83.0 | 83.0 | 0.0 |
| Ballast | At tail light | 25 | 472.0 | 472.0 | 0.0 |
| | At horizontal stabilizer | 50 | 414.0 | 414.0 | 0.0 |
| | Aft battery compartment | 100 | 284.0 | 284.0 | 0.0 |
| | Copilot station | 75 | 70.0 | 70.0 | 0.0 |
| External stores | Inboard | 862 | 195.5 | 196.65 | 0.0 |
| | Outboard | 876 | 204.1 | 198.3 | 0.0 |
| Total | | 10.214 | 199.27 | 201.18 | 0.1 right |

[1]Battery in aft compartment, station 284.
[2]Fuselage station.
[3]Buttline.

Table 2. Forward Center of Gravity Loading Example.

| Item | | Weight (lb) | Center of Gravity Location | | |
|---|---|---|---|---|---|
| | | | Intended Longitudinal (FS) | Actual Longitudinal (FS) | Lateral (BL) |
| Basic aircraft (includes instrumentation)[1] | | 6357 | 201.22 | 203.73 | 0.2 right |
| Fuel (at engine start) | | 930 | 198.7 | 204.9 | 0.0 |
| Pilot | | 220 | 135.0 | 135.0 | 0.0 |
| Copilot | | 227 | 83.0 | 83.0 | 0.0 |
| Ballast | Forward battery compartment | 100 | 35.0 | 35.0 | 0.0 |
| | Ammunition bay | 75 | 70.0 | 70.0 | 0.0 |
| | Ammunition bay | 100 | 73.0 | 73.0 | 0.0 |
| External stores | Inboard | 1134 | 195.5 | 193.3 | 0.0 |
| | Outboard | 1069 | 204.8 | 204.8 | 0.0 |
| Total | | 10,232 | 192.44 | 194.33 | 0.1 right |

[1]Battery in forward compartment, station 40.

# APPENDIX C. INSTRUMENTATION

1. Instrumentation was installed in the test aircraft by KAC prior to the start of the test program and is shown in photos 1 through 4. The telemetry package was located in the ammunition bay for all testing. All instrumentation was calibrated and maintained by KAC. The following parameters were recorded:

<u>Pilot Station</u>

Event switch
Instrumentation control

<u>Pilot Panel</u>

Airspeed (boom)
Altitude (boom)
Altitude (radar)
Rate of climb (ship's system)
Rotor speed
Engine torque
Measured gas temperature
Gas generator speed
Control position:
- Longitudinal
- Lateral
- Directional
- Collective

Center-of-gravity normal acceleration
Angle of sideslip
Attitude gyro (ship's system)
Outside air temperature (sensitive)
Outside air temperature (ship's system)

<u>Copilot/Engineer Station</u>

Event switch
Control fixtures
Airspeed (ship's system)
Rotor speed
Engine torque
Measured gas temperature
Gas generator speed
Attitude gyro

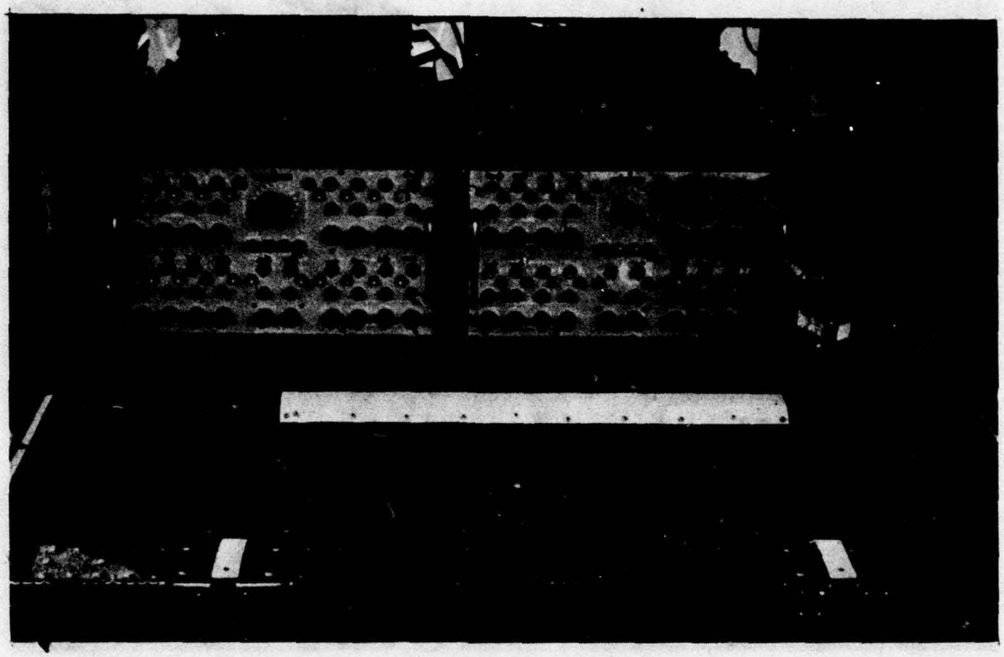


**Photo 1. Instrumentation Package in Ammo Bay - Left-Side View.**

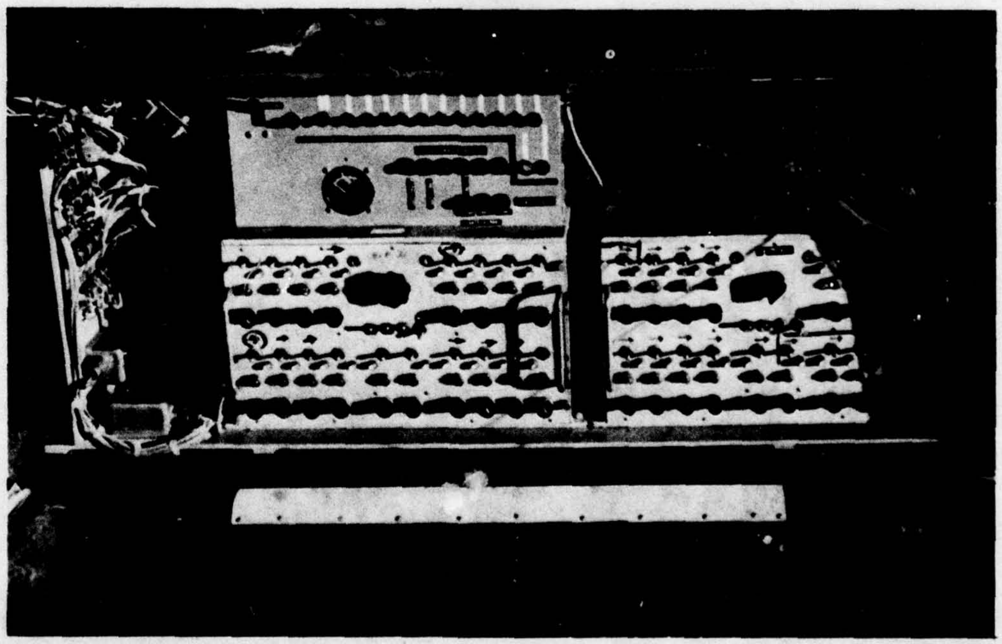


**Photo 2. Instrumentation Package in Ammo Bay - Right-Side View.**

**Photo 3. Boom-Mounted Swiveling Pitot-Static Probe and YAPS Head.**

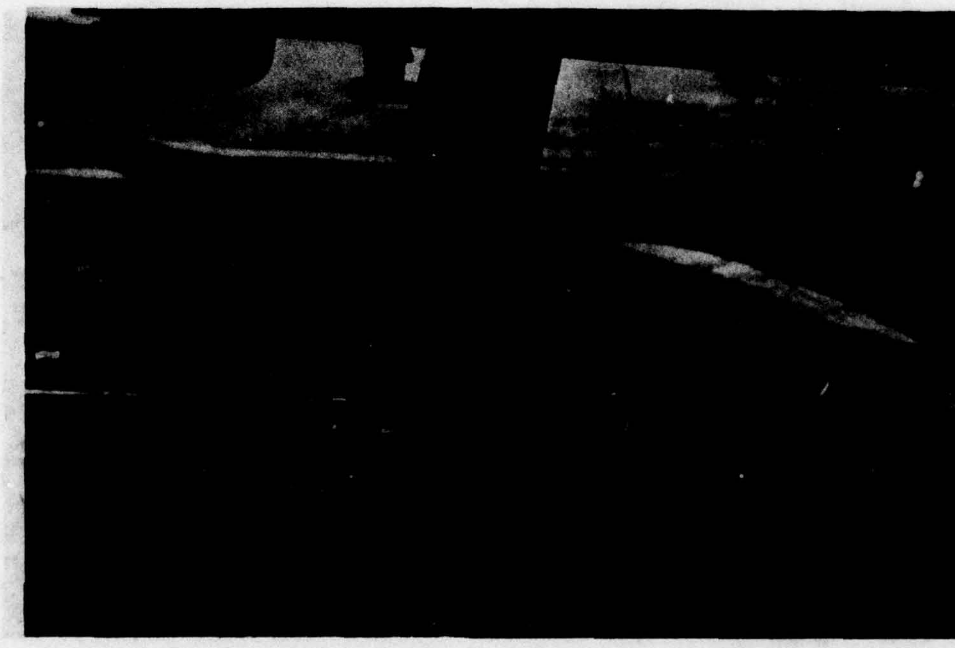


**Photo 4. Skid-Mounted Telemetry Antenna**

Fuel used (totalizer)
Time of day
Record counter

Digital (PCM) Parameters

Airspeed (boom)
Airspeed (ship's system)
Altitude (boom)
Outside air temperature
Main rotor speed (rotor blip)
Vibration acceleration:
- Pilot seat vertical
- Pilot seat lateral
- Pilot seat longitudinal
- Copilot seat vertical
- Copilot seat lateral
- Copilot seat longitudinal
- Center-of-gravity vertical
- Center-of-gravity lateral
- Center-of-gravity longitudinal

Main rotor loads:
- Pitch links(2)
- Drag brace axial (1)
- Hub station 5-flap bending

Main rotor cyclic blade angle
Fuel used at flow meter
Center-of-gravity normal acceleration
Angle of sideslip
Angle of attack
Engine output torque pressure
Fuel temperature (at flow meter)
Main rotor shaft torque
Tail rotor shaft torque
Pilot event
Engineer event
Correlation counter
Control positions:
- Longitudinal cyclic
- Lateral cyclic
- Collective
- Pedal
- Throttle

Flight control augmentation positions:
- Longitudinal
- Lateral
- Directional

Control force:
- Longitudinal
- Lateral
- Pedal
- Collective

Attitude:
- Pitch
- Roll
- Yaw

Angular velocity:
- Pitch
- Roll
- Yaw

2. External (drag producing) instrumentation included (1) nose boom with swiveling pitot-static probe mounted 7 feet forward of the nose; (2) belly-mounted sensitive OAT probe; (3) main rotor standpipe; (4) main and tail rotor slip ring assemblies; (5) main rotor hub loads instrumentation; (6) telemetry antenna with ground-plane plate mounted on skid; and (7) flush-mounted radar altimeter antennas. Neither set of main rotor blades was instrumented.

3. The instrumentation package was designed and primarily used for structural envelope expansion and flight load surveys by the contractor. As such, it was not well tailored for performance testing. Long-term or continuous recording was not practical. Several difficulties were encountered in determining OAT. The sensitive calibrated OAT had only ground (telemetered) read-out capability. Subsequent to the performance tests, a wiring error was discovered, which made this source of OAT erroneous. The standard ship's temperature probe data, which were hand-recorded intermittently during the tests, were used to process the performance data. This gage was difficult to read, being mounted through the fuselage skin behind the pilot's left knee. Reading error of ±2°C (attempts to postcalibrate it were inconclusive). Ram recovery effects are unknown. OAT's used and presented in the performance data may be in error by as much as 5°C. Subsequent to the performance tests, a calibrated sensitive OAT system with cockpit display was installed. The OAT data during handling qualities tests should be accurate within ±2°C. Recorded pressure altitude had a resolution larger than 200 feet. Recorded PCM airspeed agreed with sensitive indicated airspeeds within 2 knots. Recorded PCM rotor speed disagreed with calibrated sensitive indicators by as much as 2 rpm.

4. The airspeed calibration presented in figure 1 was obtained from the contractor. The fairing was used for all airspeed data.

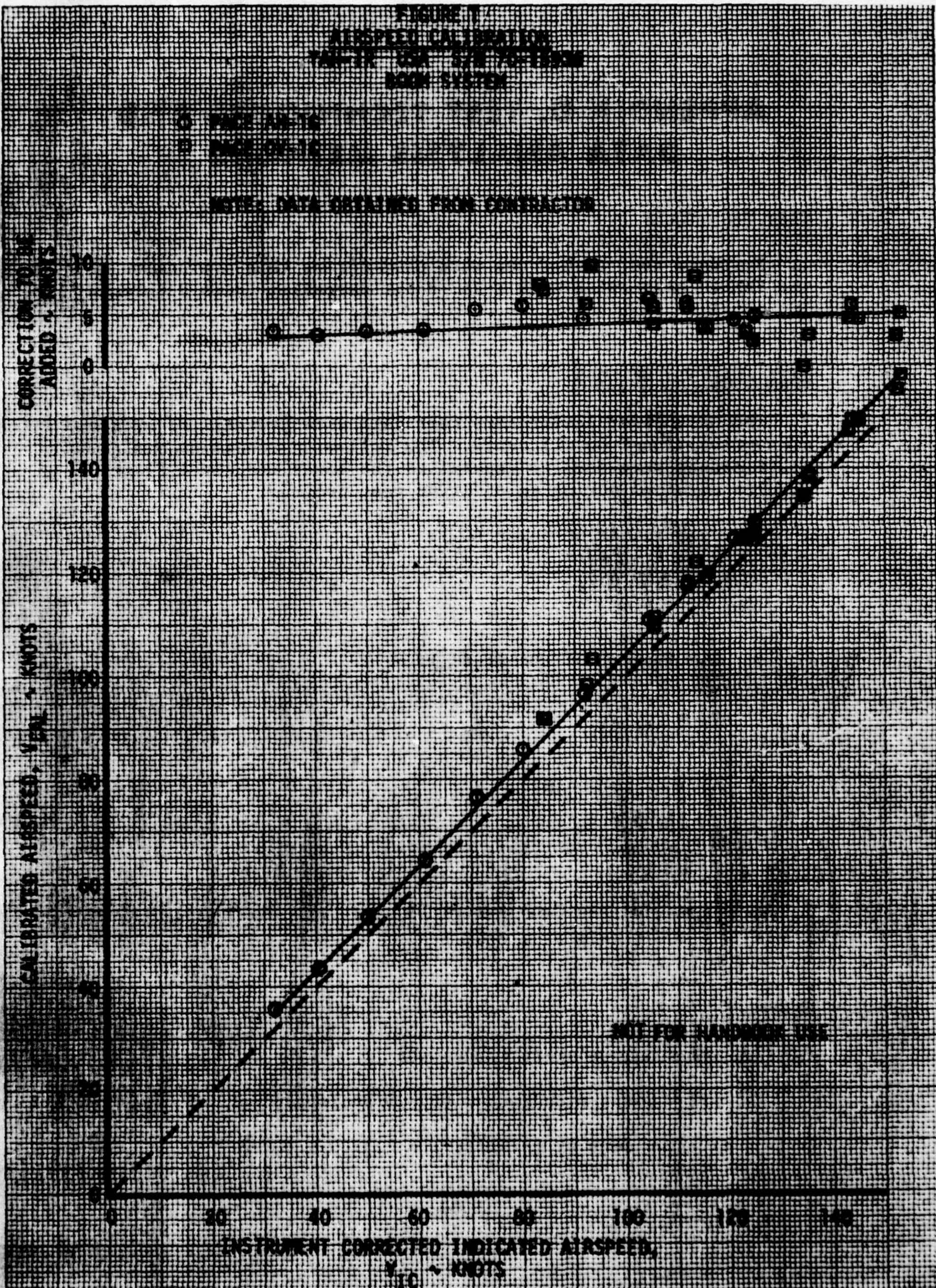


FIGURE 1
AIRSPEED CALIBRATION
BOOM SYSTEM
NOTE: DATA OBTAINED FROM CONTRACTOR
CORRECTION TO BE ADDED ~ KNOTS
CALIBRATED AIRSPEED ~ KNOTS
NOT FOR HANDBOOK USE
INSTRUMENT CORRECTED INDICATED AIRSPEED, $V_{IC}$ ~ KNOTS
0
20
40
60
80
100
120
140
5
10

# APPENDIX D. TEST TECHNIQUES AND DATA ANALYSIS METHODS

## TEST TECHNIQUES

1. Standard test techniques were used during this evaluation of the YAH-1R helicopter with K-747 rotor installed (refs 8 through 10, app A).

## DATA ANALYSIS METHODS

2. The helicopter performance test data were generalized by use of nondimensional coefficients. The following nondimensional coefficients were used to generalize the hover and level flight results obtained during this flight test program:

a. Coefficient of power ($C_P$):

$$C_P = \frac{SHP(550)}{\rho A(\Omega R)^3} \tag{1}$$

b. Coefficient of thrust ($C_T$):

$$C_T = \frac{W}{\rho A(\Omega R)^3} \tag{2}$$

c. Advance ratio ($\mu$):

$$\mu = \frac{1.6878\ V_T}{\Omega R} \tag{3}$$

d. Advancing tip Mach number ($M_{tip}$):

$$M_{tip} = \frac{1.6878\ V_T + (\Omega R)}{a} \tag{4}$$

Where:

SHP = output shaft horsepower

550 = Conversion factor (ft-lb/sec/shp)

$\rho$ = Air density (slug/ft$^3$) = $2.3769 \times 10^{-3}\,\sigma$

R = Main rotor radius (ft) = 22 ft

A = Main rotor disc area (ft$^2$) = $\Pi R^2$ = 1520.5 ft$^2$

$\Omega$ = Main rotor angular velcoity (rad/sec) = $\frac{\Pi}{30}$ x rpm

W = Aircraft gross weight (lb)

1.6878 = Conversion factor (ft/sec/kt)

$V_T$ = True airspeed (kt)

a = Speed of sound (ft/sec) = 1116.45 $\sqrt{\Theta}$

$\sigma$ = Air density ratio = $\delta/\Theta$

$\delta$ = Pressure ratio = $\left(1 - \frac{H_P}{145,442}\right)^{5.25585}$

$H_P$ = Pressure altitude (ft)

$\Theta$ = Temperature ratio = $\frac{OAT + 273.15}{288.15}$

OAT = Ambient air temperature (°C) = $\frac{(OAT_{ic} + 273.15)-273.15}{(1 + .2KM^2)}$

$OAT_{ic}$ = Observed free air temperature corrected for instrument error (°C)

M = Mach number = $\frac{V_{cal}}{661.48\sqrt{\delta}}$

K = Probe recovery factor

$V_{cal}$ = Calibrated airspeed (kt)

For a rotor speed of 324 rpm, the following constants were used:

R = 746.44

$(\Omega R)^2$ = 557,176

$(\Omega R)^3$ = 4.159 x $10^8$

3. Each level flight data point $C_P$ was corrected to the average $C_T$ for the flight. The slopes of $C_P$ versus $C_T$ from reference 8, appendix A, were read at the $\mu$ of the point and average $C_T$. This value was then multiplied by the amount the test $C_T$ was different from the average $C_T$ and the result added to the test $C_P$.

Hence:

$$C_{P_{corr}} = C_{P_{test}} + [(dC_P/dC_T)\ \mu,\ C_T \times \Delta C_T]$$

Level flight $C_P$ was then converted back to dimensional shaft horsepower as follows:

$$SHP = \frac{C_{P_{corr}}\ A\ (\Omega R)^3\ \rho_{avg}}{550}$$

4. All computed atmospheric parameters were determined using 1962 U.S. standard atmosphere constants and functions.

5. Engine start gross weight was determined by adding crew weight, ballast weight, and engine start fuel weight, as determined during preflight by an external sight gage quantity reading and fuel specific weight, to aircraft empty weight (app B). Test point gross weight was then computed by subtracting fuel used, obtained from a fuel volume totalizer, multiplied by the preflight specific weight corrected for temperature difference between preflight fuel temperature and test point fuel temperature. Postflight fuel quantity was also determined using the sight gage and specific weight readings. This value was compared to fuel used as computed from the fuel totalizer.

6. Test shaft horsepower was determined by multiplying rotor speed by engine torque and appropriate gear ratios and conversion constants.

$$SHP = \frac{(N_R \times 20.383) \times \text{torque, ft-lb}}{5252.1}$$

$$SHP = \frac{N_R \times \text{torque}}{257.67}$$

Engine torque was determined by measuring differential torquemeter output pressure and applying the individual engine torquemeter conversion. The nominal conversion is 18.4 ft-lb/psi. The conversion for the test engine, SN LE 15124Z, was 1125 ft-lb/63.4 psi or 17.7 ft-lb/psi. These values were obtained from engine acceptance records and the engine data plate. During earlier contractor flights, use of this conversion resulted in substantial disagreement between engine torque and the sum of rotor shaft torques plus accessory losses. Also, performance data obtained by the contractor using the B-540 rotor disagreed with previous

B-540 data obtained with the YAH-1S (ref 8, app A). Use of the torque conversion function from reference 8 caused the contractor B-540 performance data and reference 8 data to agree and caused closer agreement between engine torque and the sum of shaft torques and accessory losses. This function was then used as being typical of the T53-L-703 series engine for both the contractor data and this project. The conversion is:

$$\text{Torque, ft-lb} = 0.13466 + 17.885\ QE + 3.8434 \times 10^{-3}\ QE^2$$

Where:

QE = Differential torquemeter pressure

Subsequent to this test and data analysis for this project, data from a 19-point engine calibration were obtained for the test engine. Use of the torque conversion derived from these data resulted in even better agreement between engine torque and the sum of rotor shaft torques plus accessory losses. However, it degraded the comparison between reference 8 data and contractor B-540 rotor data. This conversion is:

$$\text{Torque, ft-lb} = 18.331 + 22.362\ QE - 0.12787\ QE^2 + 1.145 \times 10^{-3}\ QE^3$$

Using this conversion would increase the power required shown in this report by approximately 2 percent. A further engine calibration was conducted and verified the original 19 point calibration.

7. Vertical speed for both climbs and autorotational descents was determined by measuring the time required to change altitude 1000 feet. This was converted to the rate of climb (descent) as follows:

$$R/C_{time} = \frac{\Delta H_P}{\Delta time}\left(\frac{OAT_{test} + 273.15}{OAT_{std} + 273.15}\right)$$

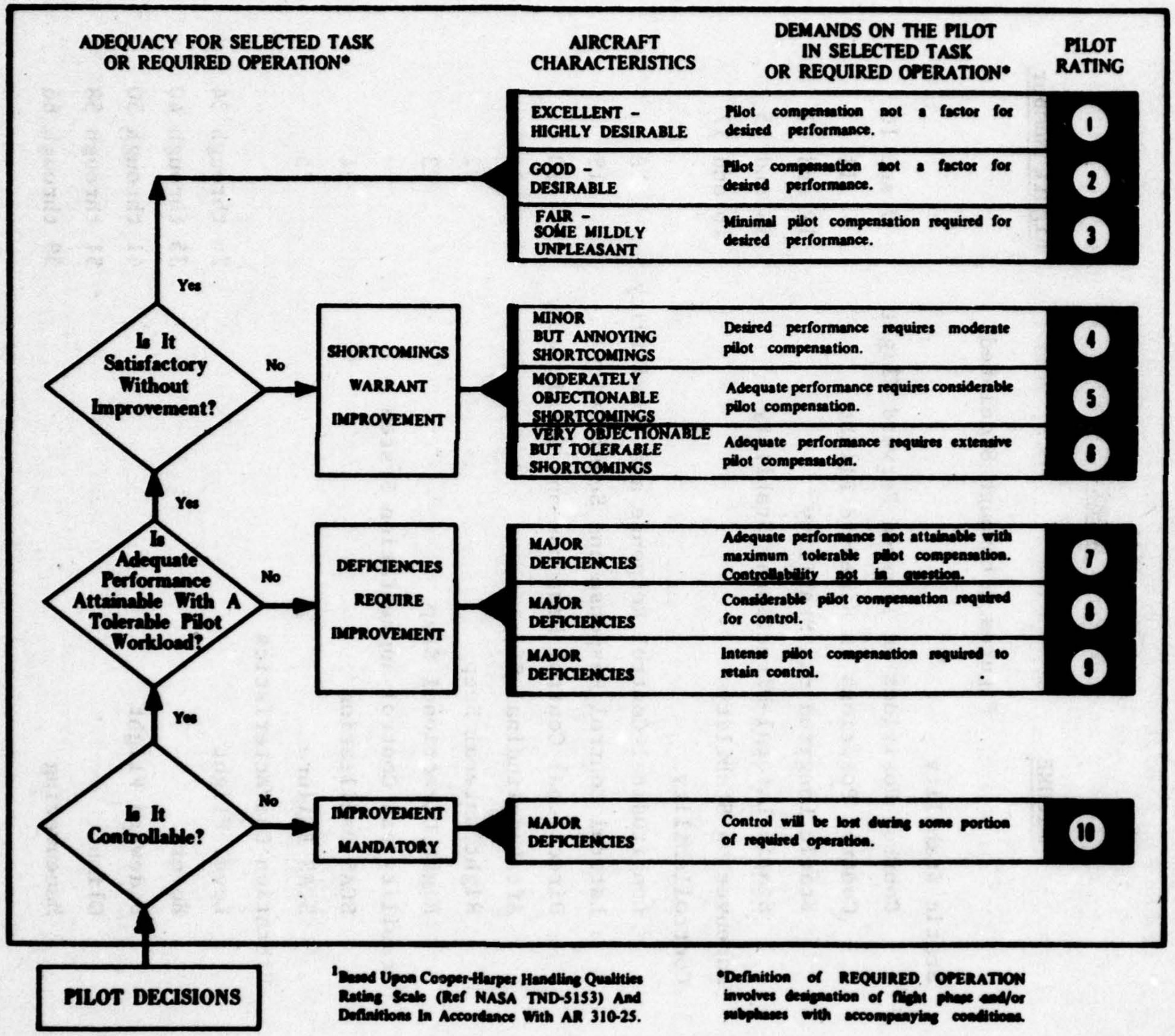
8. To determine the climb correction factors, the rates of climb were further corrected to average powers or gross weights as follows. For determining $K_P$, rates of climb were corrected to the average gross weight using:

$$R/C_{wt\text{-}corr} = R/C_{test} + KW\left[\frac{\Delta GW}{GW^2} \times 33{,}000\ SHP_{test}\right]$$

For determining $K_W$, rates of climb were corrected to the average shaft horsepower of a set using:

$$R/C_{pwr\text{-}corr} = R/C_{test} + \left[ K_P \frac{\Delta SHP \times 33{,}000}{GW} \right]$$

9. Handling qualities ratings were quantified using figure 1.




[1]Based Upon Cooper-Harper Handling Qualities Rating Scale (Ref NASA TND-5153) And Definitions In Accordance With AR 310-25.

*Definition of REQUIRED OPERATION involves designation of flight phase and/or subphases with accompanying conditions.

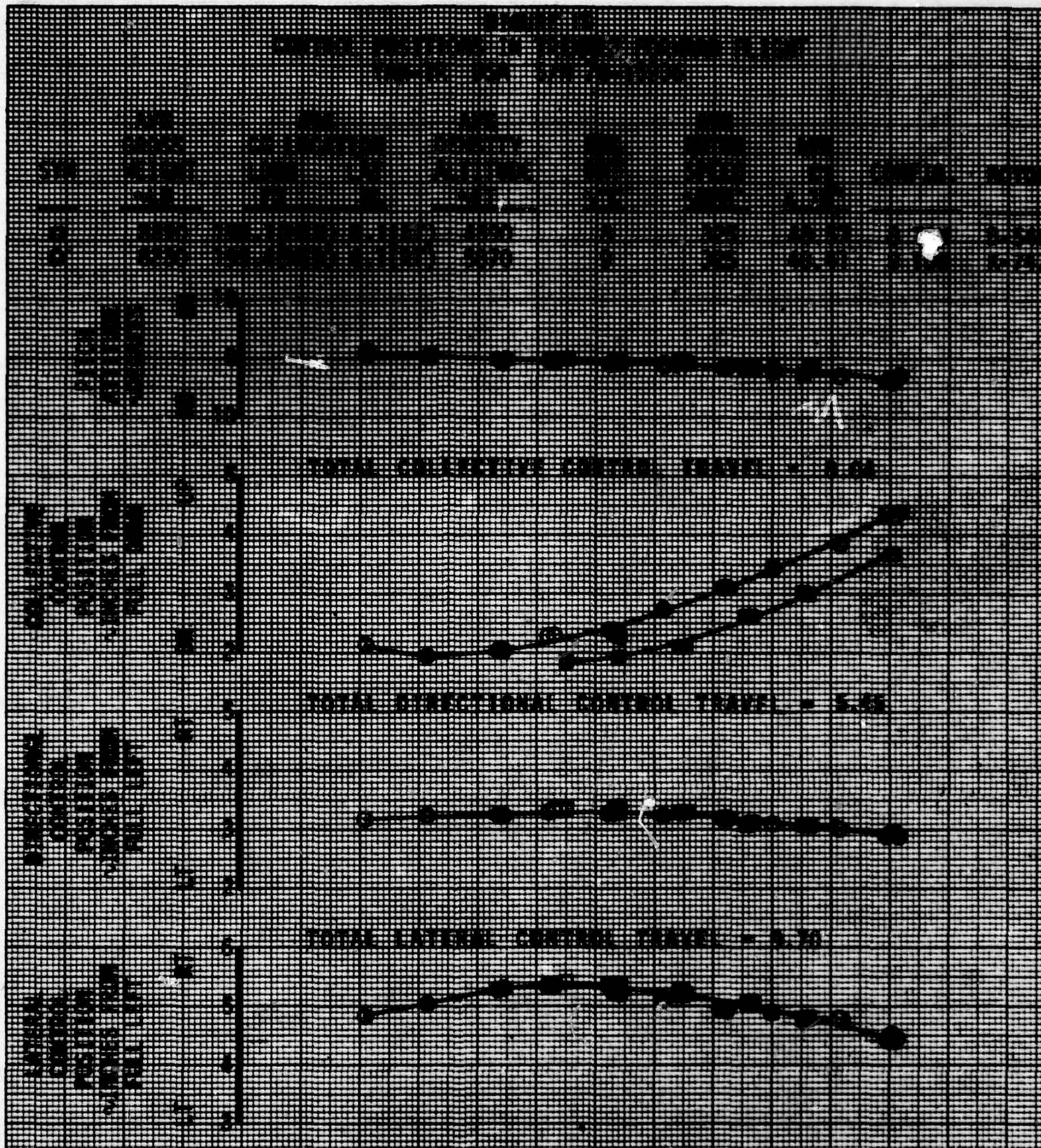
Figure 1. Handling Qualities Rating Scale.

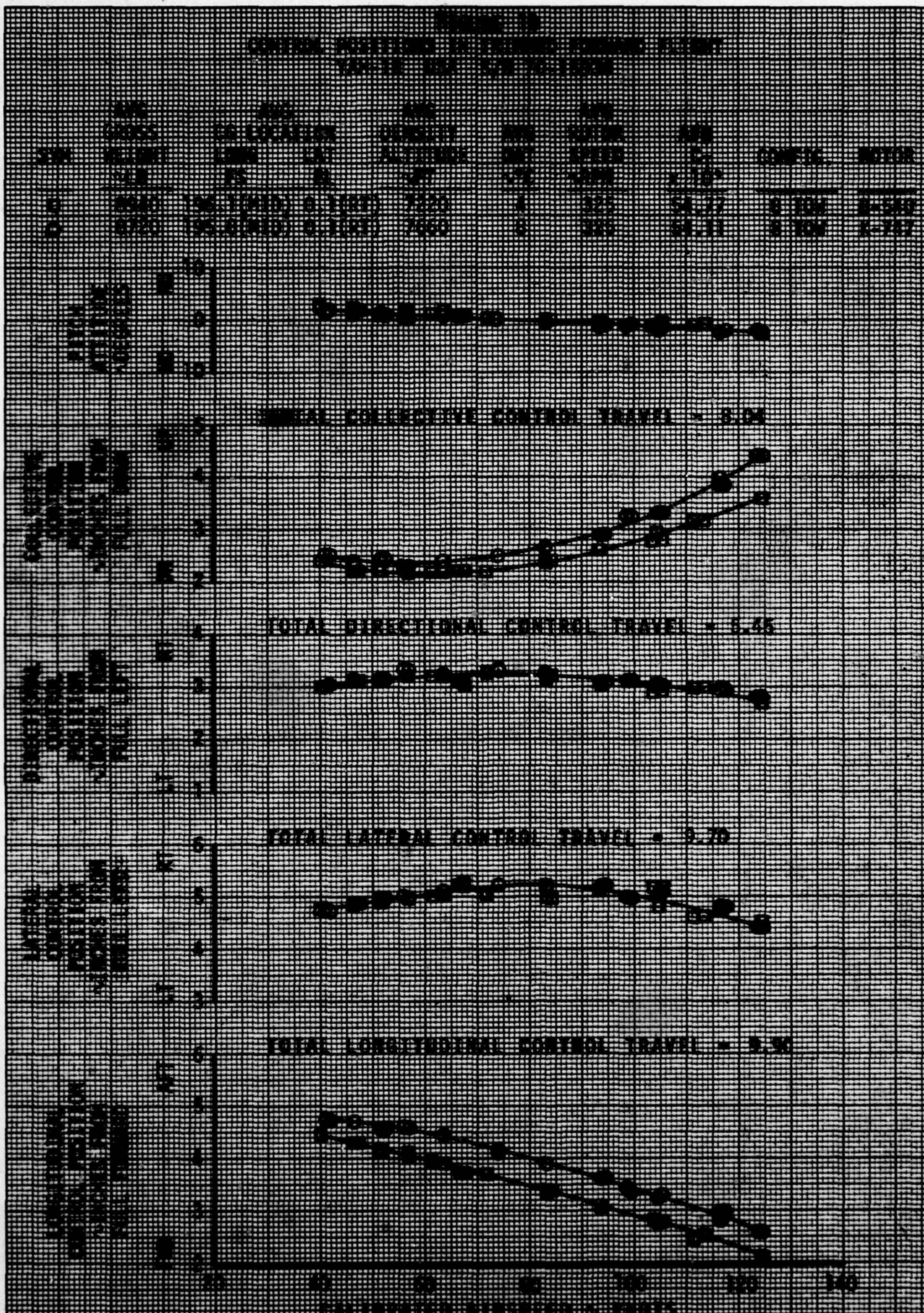
# APPENDIX E. TEST DATA

## INDEX

# APPENDIX E. TEST DATA

INDEX


30
40
50
60
70
80
90
100
110
120
130
140
CALIBRATED AIRSPEED ~ KNOTS



TOTAL DIRECTIONAL CONTROL TRAVEL = 5.45
TOTAL LATERAL CONTROL TRAVEL = 9.70
TOTAL LONGITUDINAL CONTROL TRAVEL = 9.90
20
40
60
80
100
120
140
CALIBRATED AIRSPEED ~ KNOTS

FIGURE 12
CONTROL POSITIONS IN STANDARD FLIGHT
YAH-1R USA S/N 70-15936

| SYM | AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENSITY ALTITUDE ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ $\times 10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| — — — | 9940 | 192.2(FWD) | -0.1(LT) | -300 | 7 | 324 | 48.93 | HOG | B-540 |
| —◆— | 9540 | 195.2(MID) | 0.1(RT) | -2820 | -7 | 324 | 42.77 | B 10W | K-747 |

NOTES: 1. SKID HEIGHT = 10 FEET
2. DASHED CURVES OBTAINED FROM REF 9

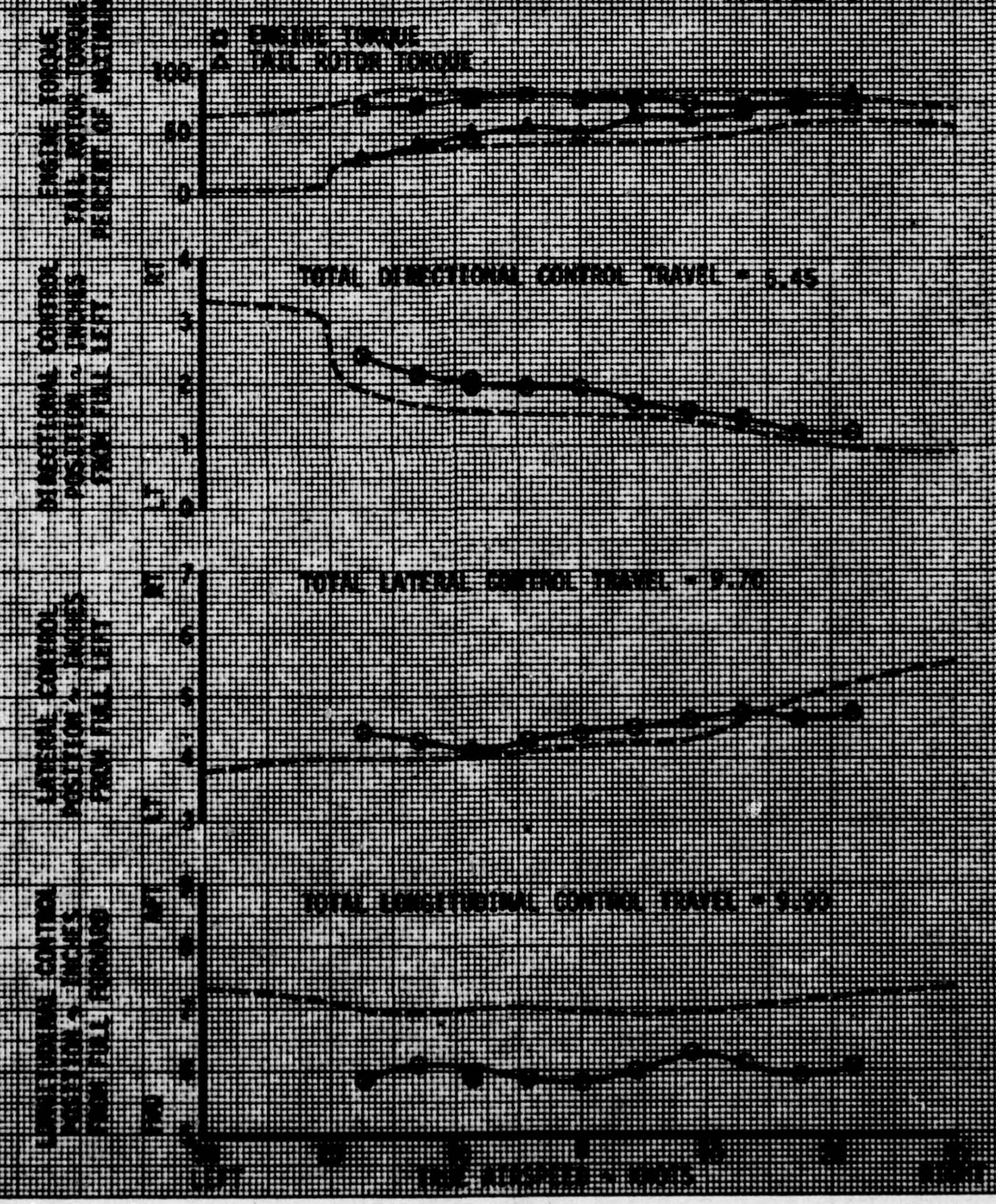
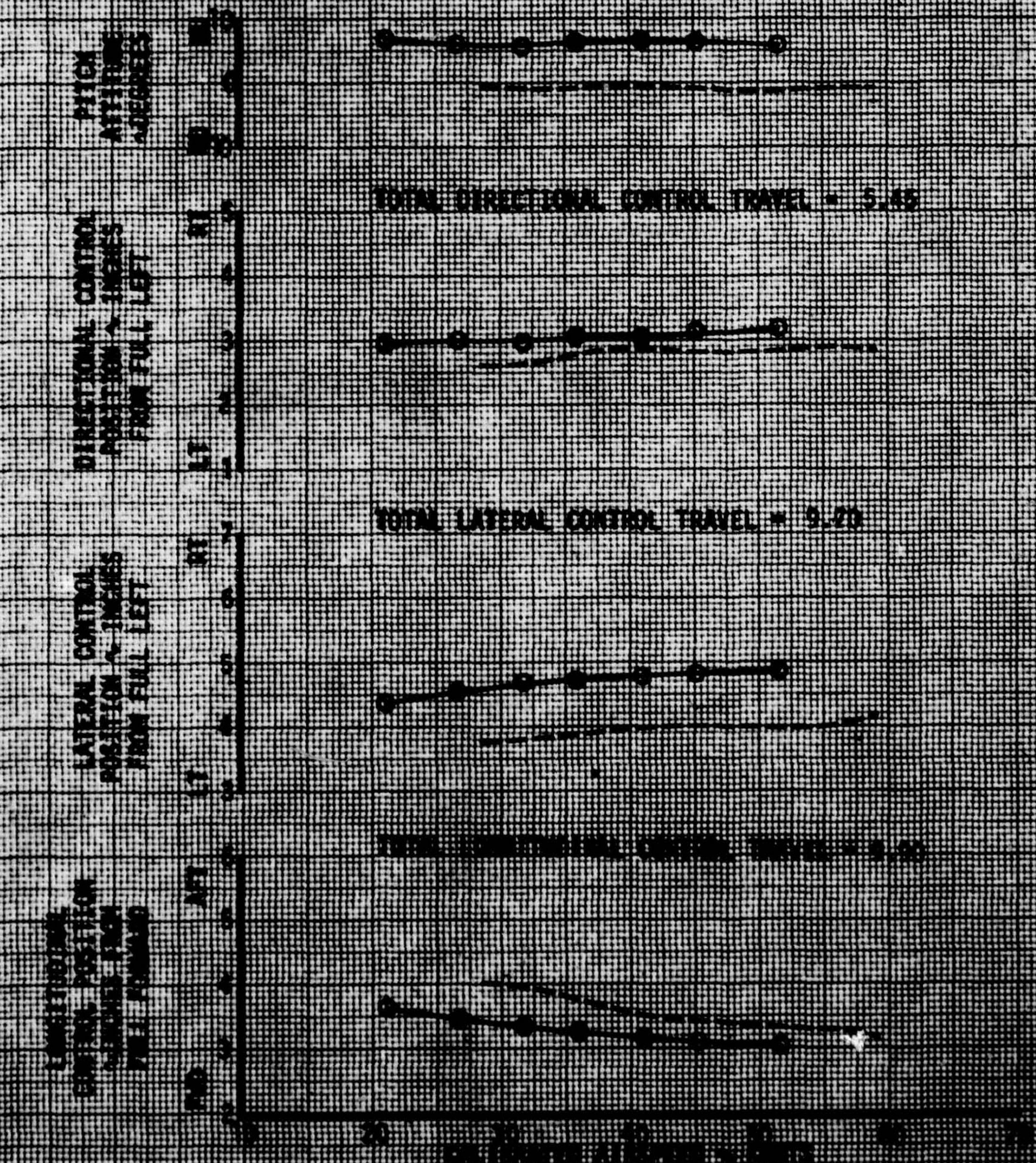
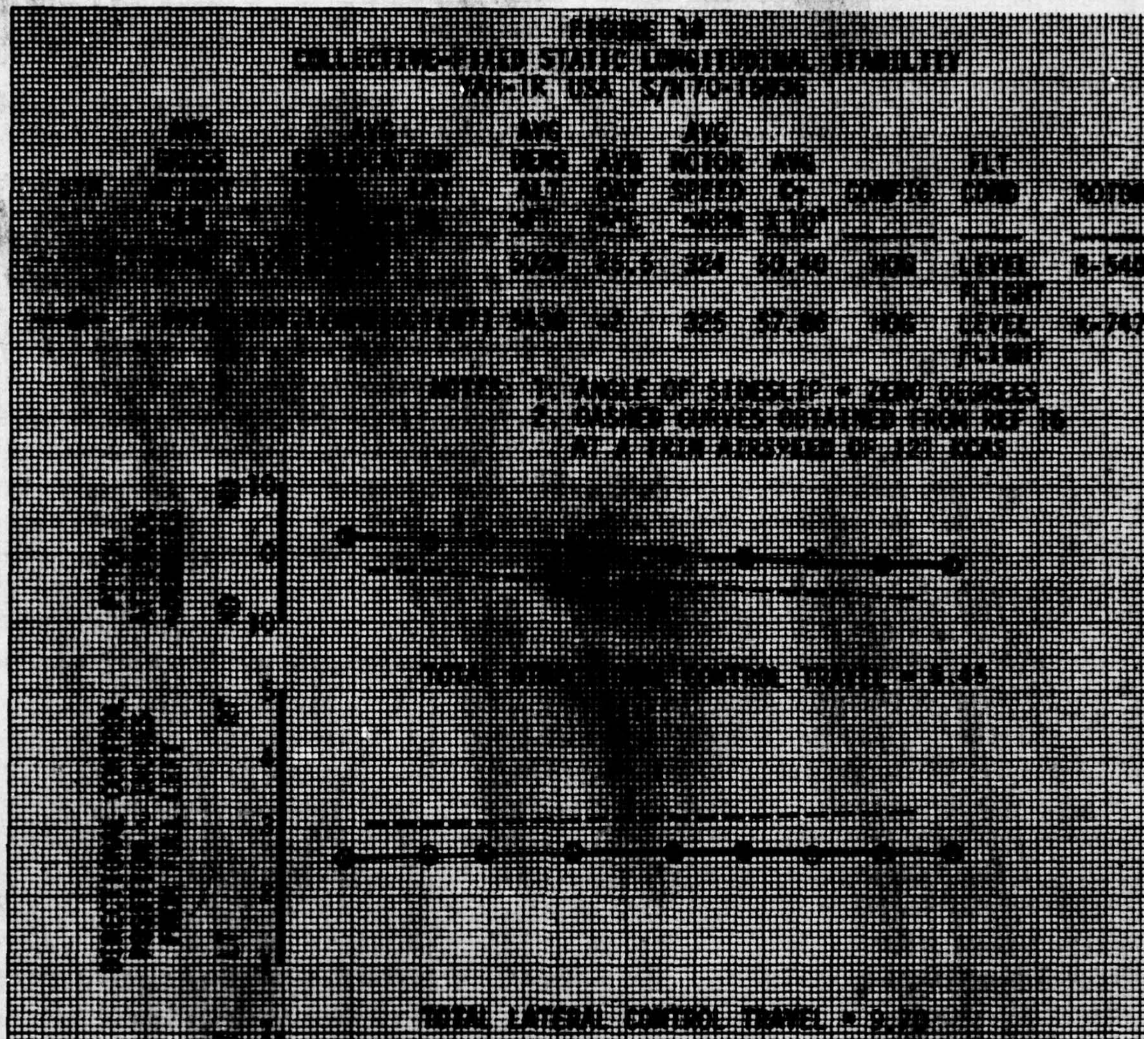


FIGURE 38
COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
YAH-1R USA S/N 70-15936

| SYM | AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENS ALT ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ $\times 10^4$ | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| dashed line | 10000 | 199.8(AFT) | -0.1(LT) | 6100 | 2.5 | 324 | 58.27 | HOG | LEVEL FLIGHT | B-540 |
| —●— | 9680 | 200.0(AFT) | 0.1(RT) | 4760 | -4 | 325 | 55.04 | HOG | LEVEL FLIGHT | K-747 |

NOTES: 1. ANGLE OF SIDESLIP = ZERO DEGREES
2. DASHED CURVES OBTAINED FROM REF 9 AT A TRIM AIRSPEED OF 46.5 KCAS




COLLECTIVE-FIXED STATIC LONGITUDINAL STABILITY
AVG
AVG
AVG
AVG
ROTOR
AVG
FLT
SPEED
COND
ROTOR
LEVEL
LEVEL
NOTES: 1. ANGLE OF SIDESLIP = ZERO DEGREES
TOTAL LATERAL CONTROL TRAVEL = 9.70
CALIBRATED AIRSPEED ~ KNOTS
90
100
110
120
130
140
150

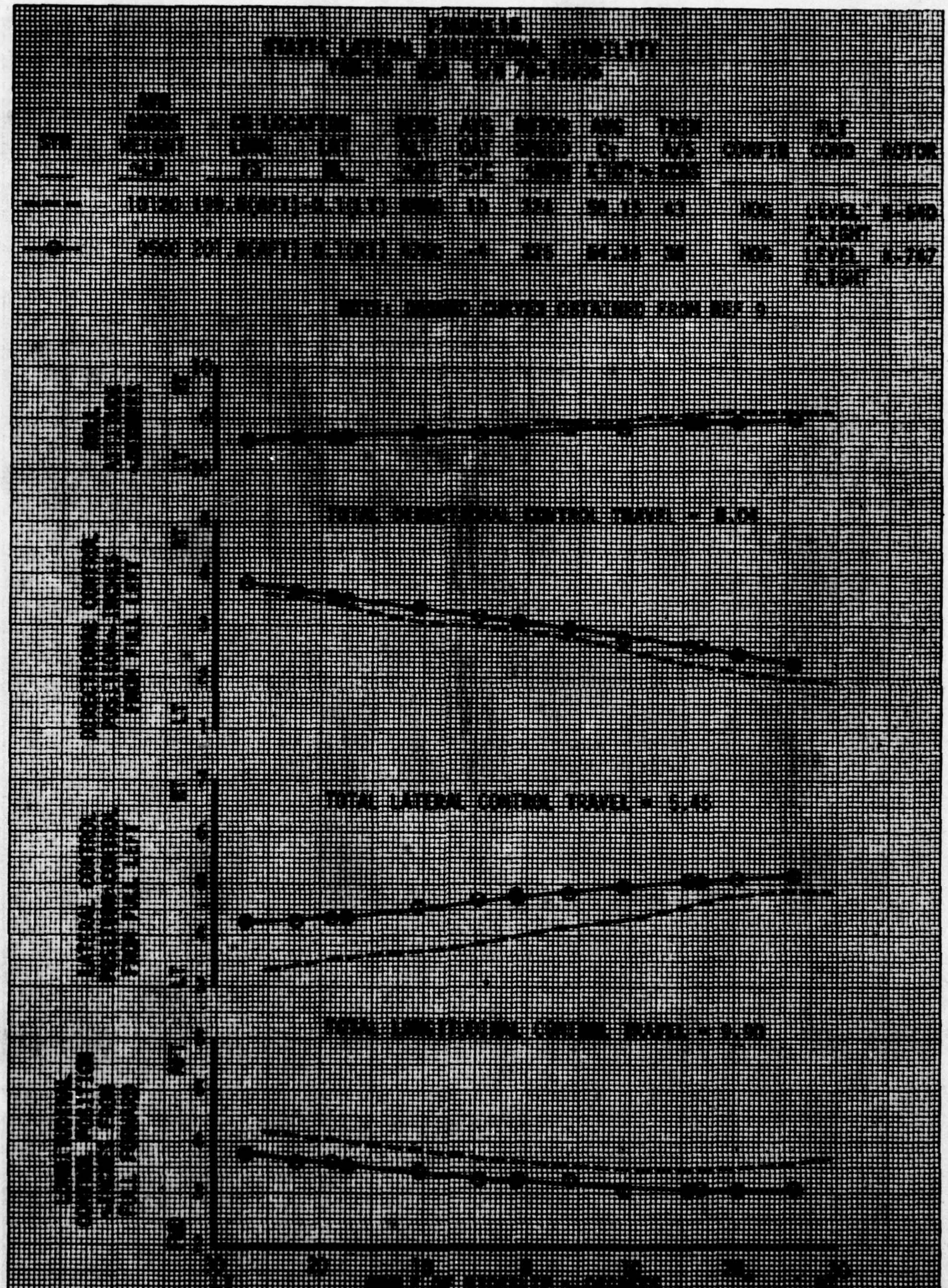
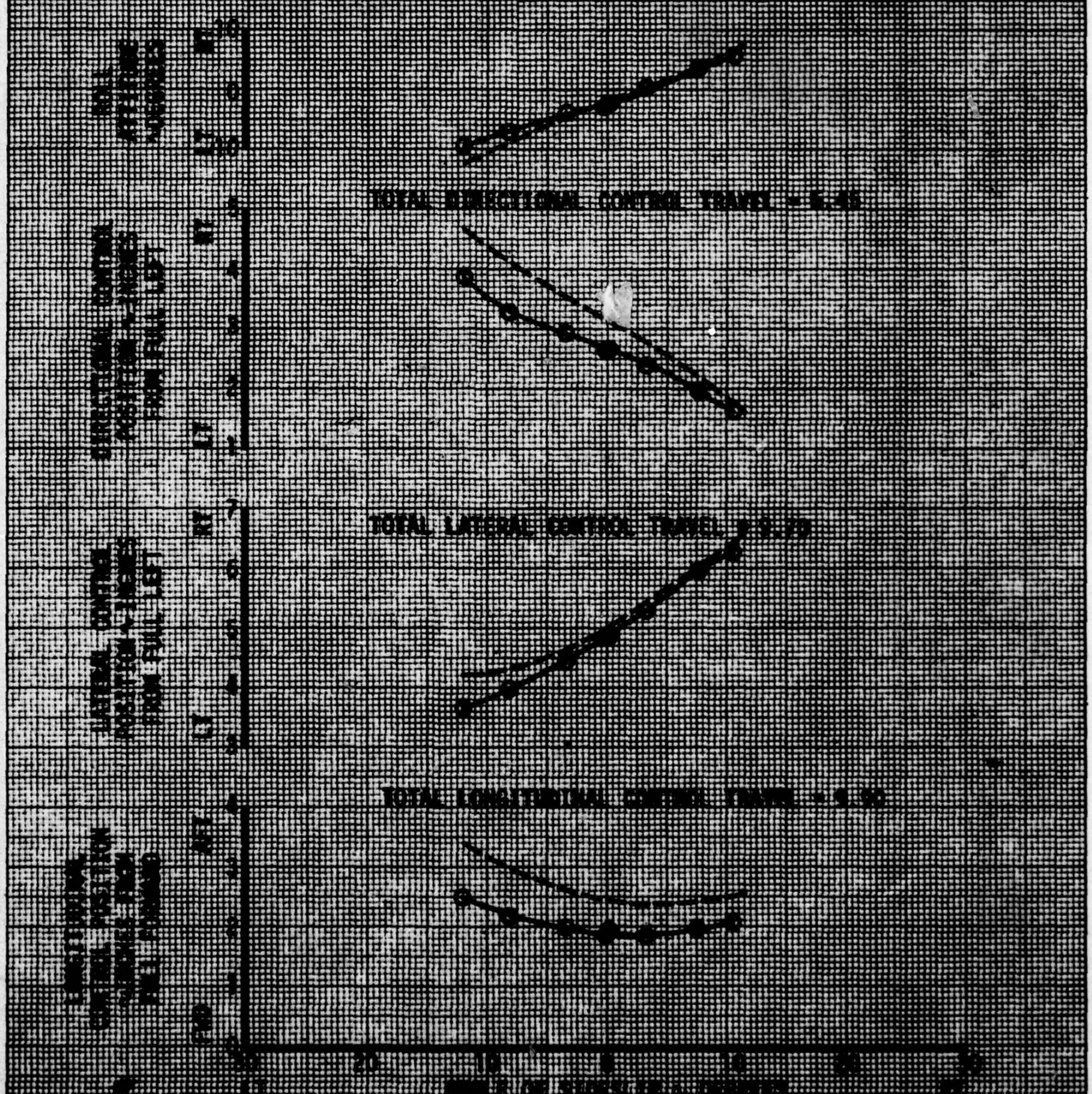
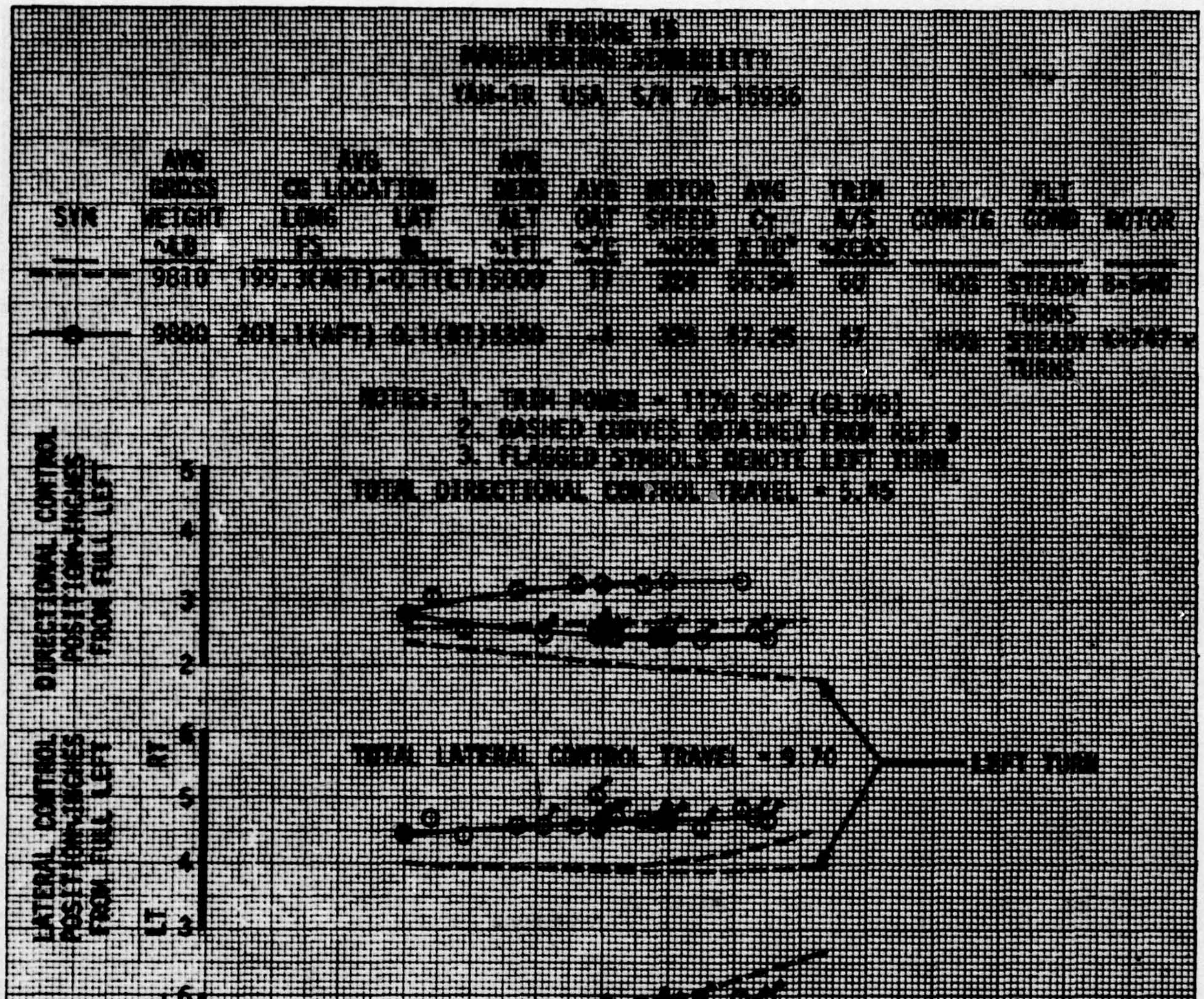

TOTAL DIRECTIONAL CONTROL TRAVEL
TOTAL LATERAL CONTROL TRAVEL
TOTAL LONGITUDINAL CONTROL TRAVEL
LEVEL FLIGHT

FIGURE [illegible]
STATIC LATERAL DIRECTIONAL STABILITY
YAH-1R USA S/N 70-15936

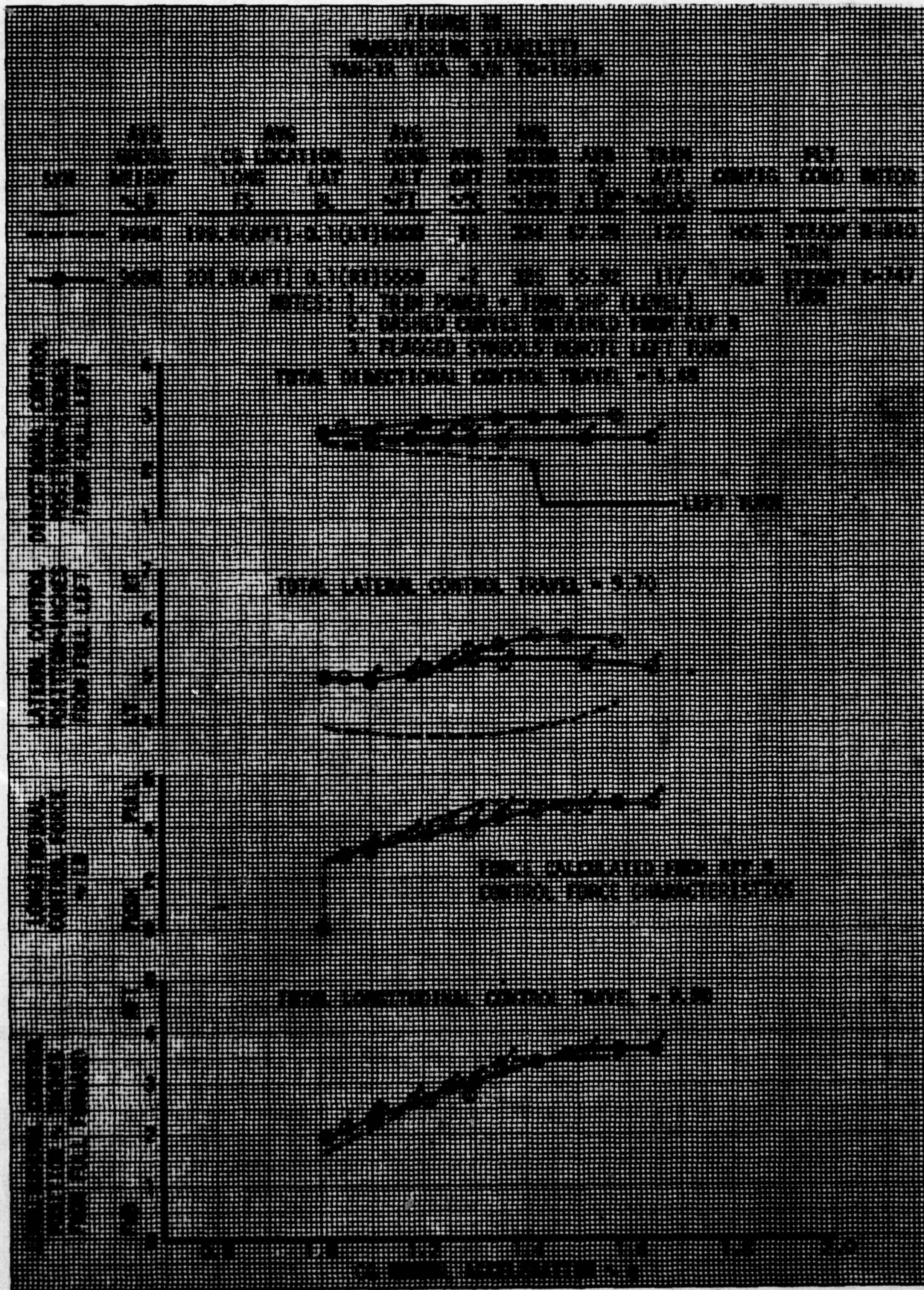
| SYM | AVG GROSS WEIGHT (LB) | AVG CG LOCATION LONG (FS) | AVG CG LOCATION LAT (BL) | AVG DENS ALT (FT) | AVG OAT (°C) | AVG ROTOR SPEED (RPM) | AVG $C_T$ ($\times 10^4$) | TRIM CAS (KCAS) | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| dashed line | 8570 | 199.5(AFT) | | 4880 | 15 | 324 | 59.76 | 127 | HGS | LEVEL FLIGHT | B-540 |
| solid line with circles | 9020 | 201.4(AFT) | 0.1(RT) | 5050 | -2 | 325 | 56.33 | 118 | HGS | LEVEL FLIGHT | K-747 |

NOTE: DASHED CURVES OBTAINED FROM REF 12





USA S/N 70-15936
AVG GROSS WEIGHT
AVG CG LOCATION
LONG
LAT
AVG ROTOR SPEED
TRIM
SYM
CONFIG
ROTOR
9810
9880
STEADY TURNS
TOTAL DIRECTIONAL CONTROL TRAVEL
TOTAL LATERAL CONTROL TRAVEL
LEFT TURN
FORCE CALCULATED FROM REF
CONTROL FORCE CHARACTERISTICS
TOTAL LONGITUDINAL CONTROL TRAVEL
DIRECTIONAL CONTROL POSITION ~ INCHES FROM FULL LEFT
LATERAL CONTROL POSITION ~ INCHES FROM FULL LEFT
LONGITUDINAL CONTROL FORCE ~ LB
PUSH
PULL
LONGITUDINAL CONTROL POSITION ~ INCHES FROM FULL FORWARD
FWD
AFT
LT
RT
0.8
1.0
1.2
1.4
1.6
1.8
2.0
CG NORMAL ACCELERATION ~ G



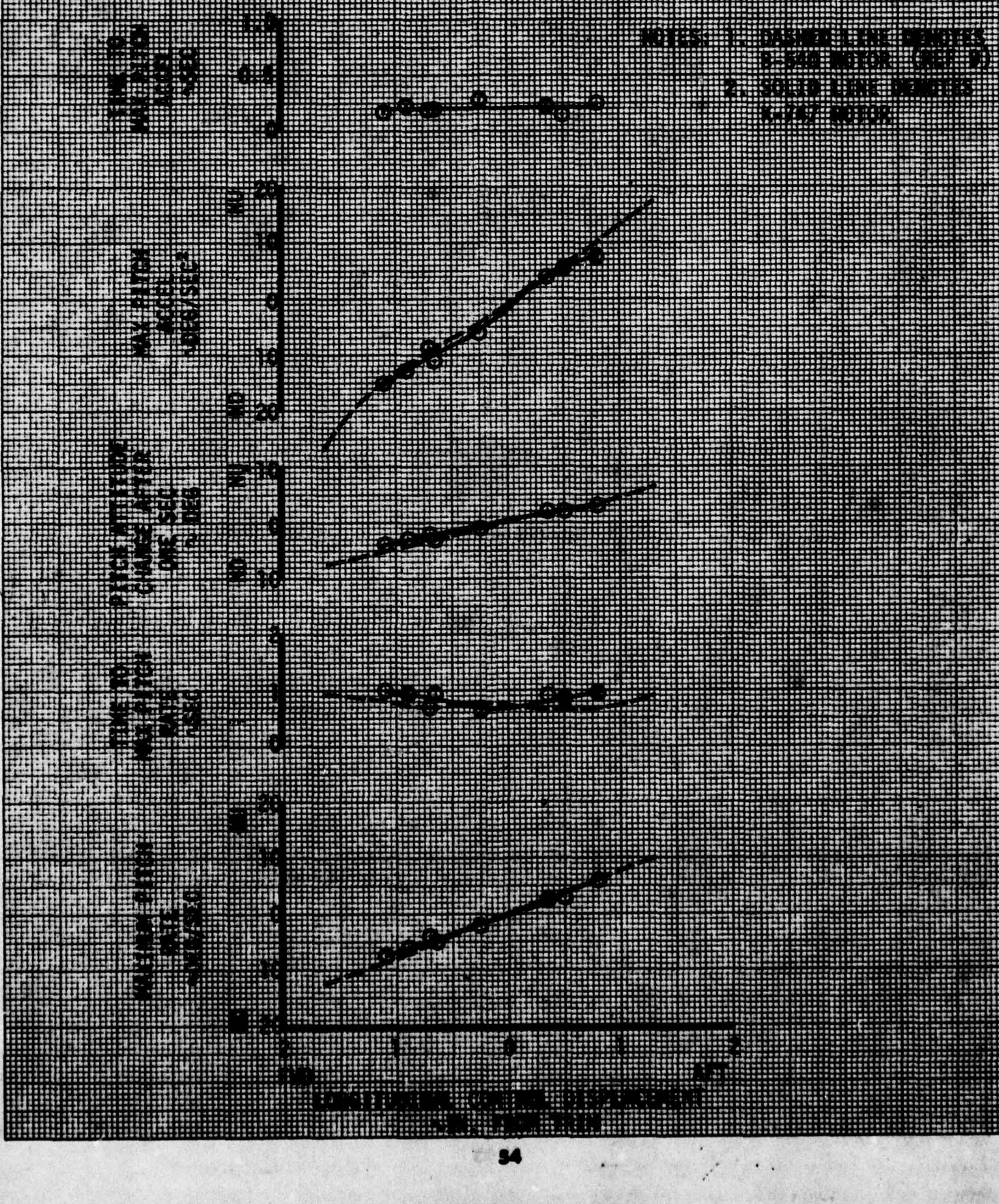
NOTES:
TOTAL DIRECTIONAL CONTROL TRAVEL
TOTAL LATERAL CONTROL TRAVEL
TOTAL LONGITUDINAL CONTROL TRAVEL

FIGURE 30

LONGITUDINAL CONTROL RESPONSE AND SENSITIVITY

YAH-1R USA S/N 70-15936

| SYM | AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENS ALT ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ $\times 10^4$ | TRIM A/S ~KCAS | SKID HEIGHT ~FT | CONFIG |
|---|---|---|---|---|---|---|---|---|---|---|
| — — — | 9600 | 191.8(FWD) | -0.1(LT) | 700 | 13 | 324 | 46.66 | HOVER | 200 | HOG |
| —○— | 10130 | 194.6(MID) | 0.1(RT) | -3350 | -9 | 324 | 45.10 | HOVER | 50 | HOG TOW |



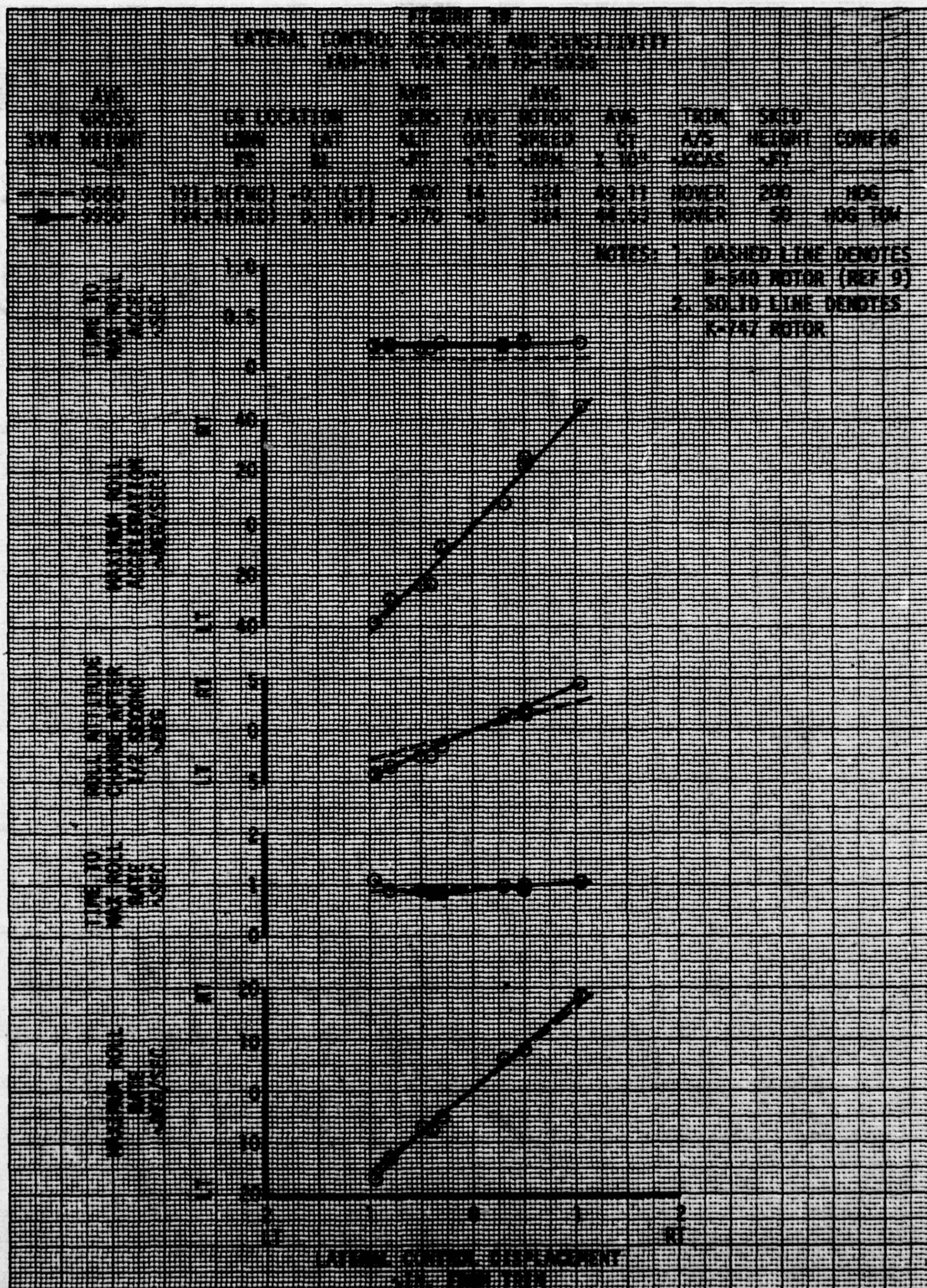

LATERAL CONTROL RESPONSE AND SENSITIVITY
SYM
AVG GROSS WEIGHT
CG LOCATION
LONG
LAT
AVG DENS ALT
AVG OAT
AVG ROTOR SPEED
AVG CT
TRIM A/S
SKID HEIGHT
CONFIG
HOVER
200
HOG
HOVER
50
HOG TOW
NOTES: 1. DASHED LINE DENOTES B-540 ROTOR (REF 9)
2. SOLID LINE DENOTES K-747 ROTOR
TIME TO MAX ROLL ACCEL
MAXIMUM ROLL ACCELERATION
ROLL ATTITUDE CHANGE AFTER 1/2 SECOND
TIME TO MAX ROLL RATE
MAXIMUM ROLL RATE
LT
RT
LATERAL CONTROL DISPLACEMENT

FIGURE [illegible]

DIRECTIONAL CONTROL RESPONSE AND SENSITIVITY

[illegible] USA S/N [illegible]

| SYM | AVG GROSS WEIGHT ~LB | CG LOCATION LONG | CG LOCATION LAT | AVG DENS ALT ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ $\times 10^4$ | TRIM A/S ~KCAS | SKID HEIGHT ~FT | CONFIG |
|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible](FWD) | [illegible](LT) | [illegible] | [illegible] | 324 | [illegible] | HOVER | 10 | HOG |
| [illegible] | [illegible] | [illegible](MID) | [illegible](RT) | [illegible] | [illegible] | 324 | [illegible] | HOVER | 50 | HOG TOW |

NOTES: 1. DASHED LINE DENOTES B-540 ROTOR (REF 9)
2. SOLID LINE DENOTES K-747 ROTOR

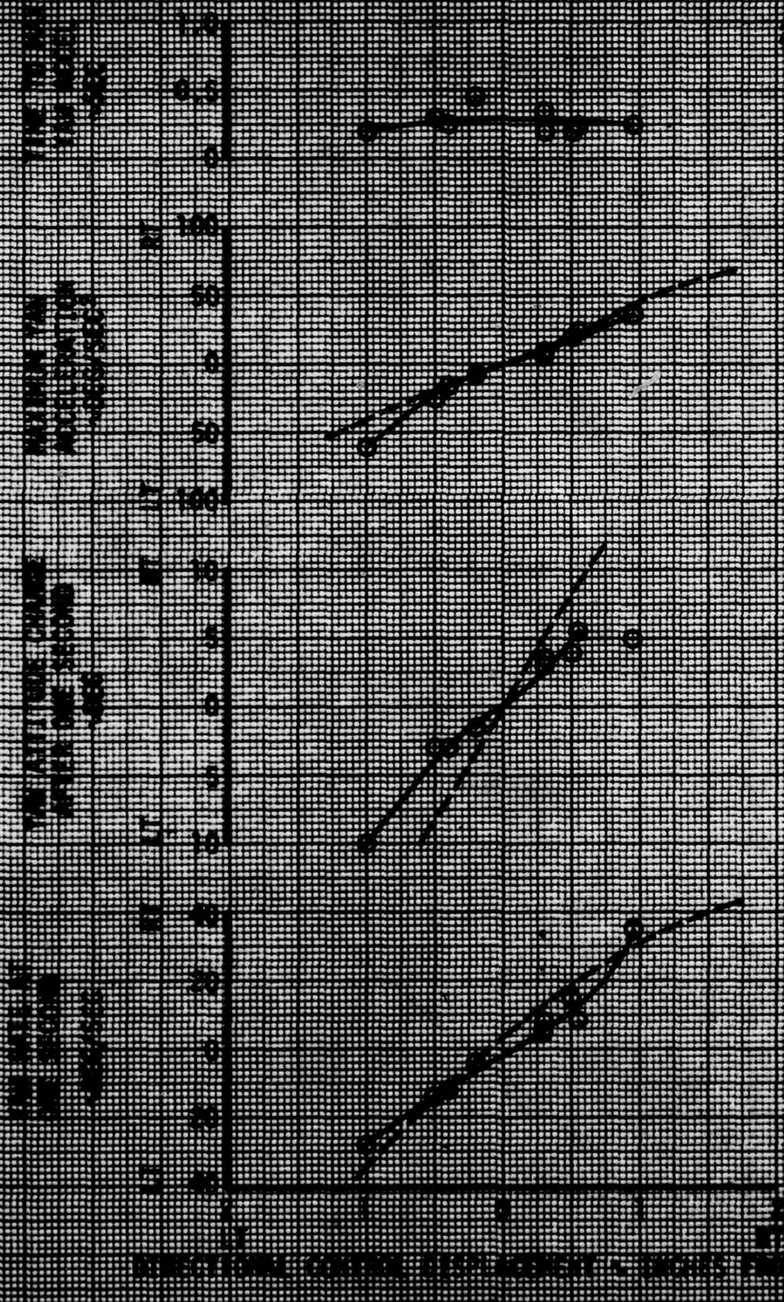


FIGURE 27
AFT LONGITUDINAL STEP
YAH-1R USA S/N 70-15936

| SOLID LINE | LONG DASH | SHORT DASH |
|---|---|---|

| GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DEN ALT ~FT | OAT ~°C | ROTOR SPEED ~ RPM | $C_T$ x $10^4$ | SKID HEIGHT ~ FT | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 10,130 | 194.6(MID) | 0.1(RT) | -3350 | -9 | 324 | 44.53 | 50 | HOG TOW | HOVER | K-747 |

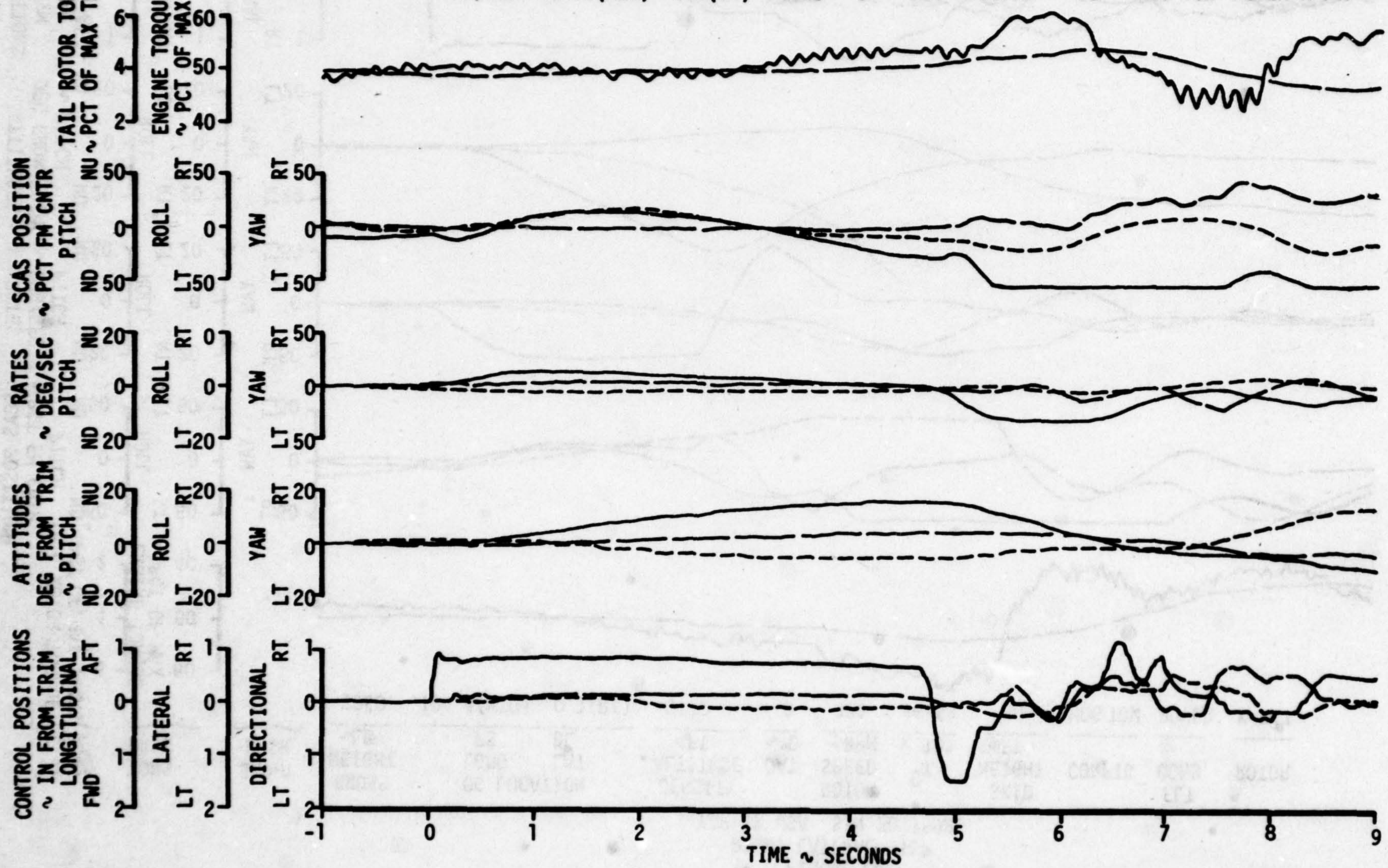


FIGURE 22
RIGHT LATERAL STEP
YAH-1R USA S/N 70-15936

| GROSS WEIGHT ~LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~FT | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ x $10^4$ | SKID HEIGHT ~FT | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9950 | 194.4(MID) | 0.1(RT) | -3170 | -8 | .324 | 44.53 | 50 | HOG TOW | HOVER | K-747 |

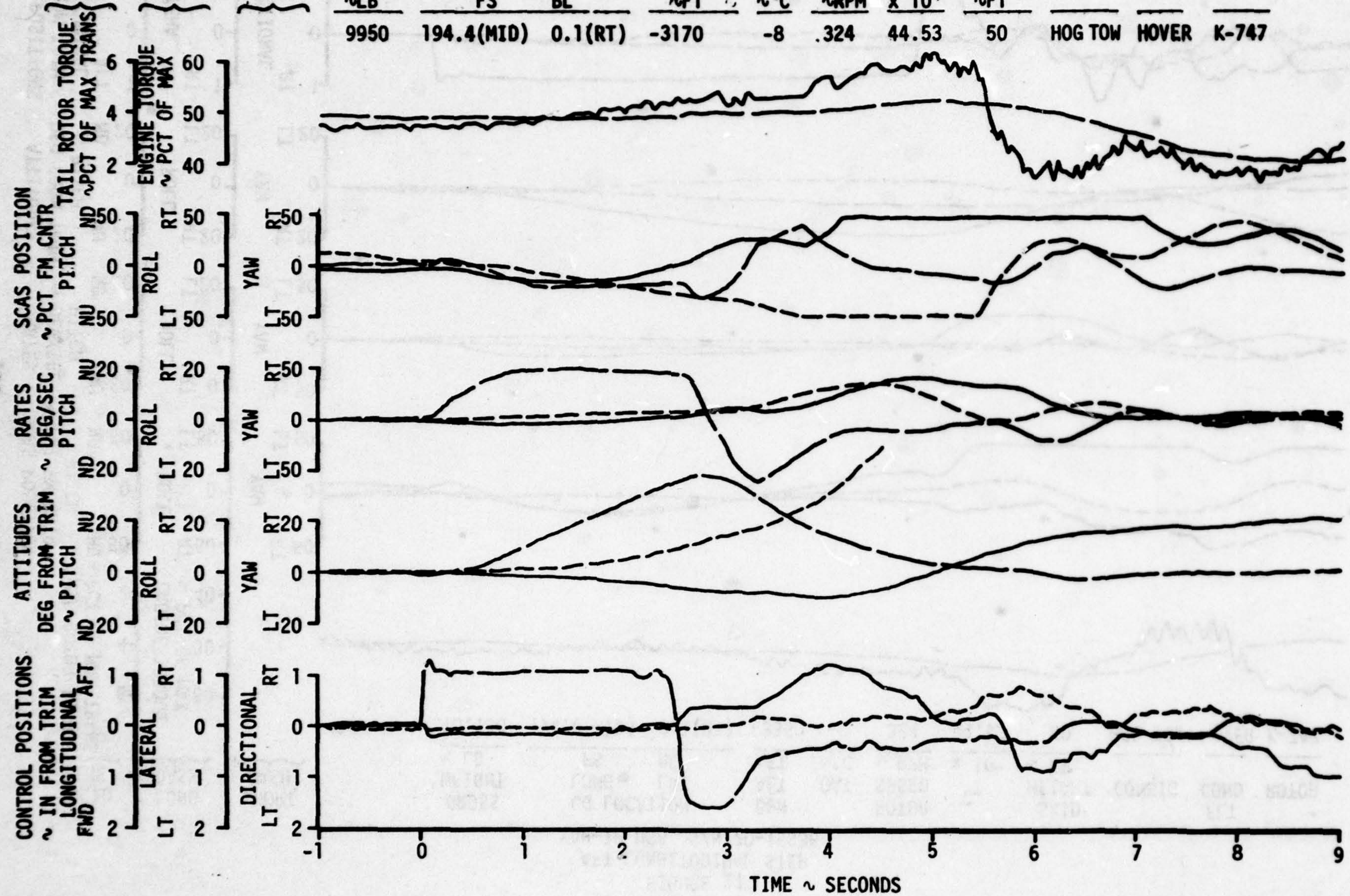


FIGURE 23
RIGHT DIRECTIONAL STEP
YAH-1R USA S/N 70-15936

| GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DEN ALT ~FT | OAT ~°C | ROTOR SPEED ~ RPM | $C_T$ x $10^4$ | SKID HEIGHT ~ FT | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9800 | 194.3(MID) | 0.1(RT) | -3200 | -8 | 324 | 43.82 | 50 | HOG TOW | HOVER | K-747 |

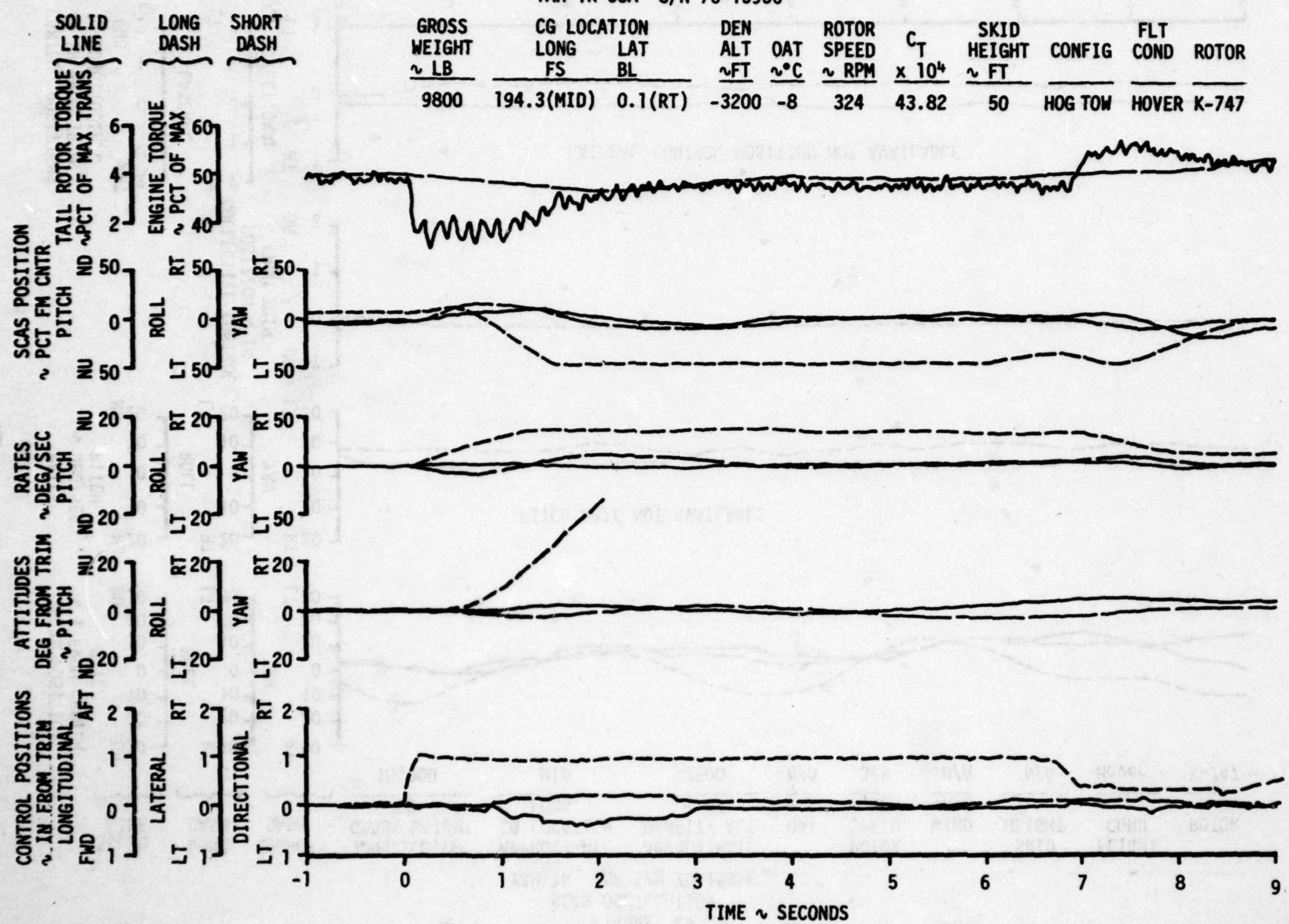


FIGURE 24
SCAS OSCILLATION
YAH-1R USA S/N 70-15936

| SOLID LINE | LONG DASH | SHORT DASH | APPROXIMATE GROSS WEIGHT ~ LB | APPROXIMATE CG LOCATION LONG | APPROXIMATE DENSITY ALT ~ FT | OAT ~°C | ROTOR SPEED ~ RPM | WIND ~KTS | SKID HEIGHT | FLIGHT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 10,000 | MID | -2500 | N/A | 325 | N/A | N/A | Hover | K-747 |

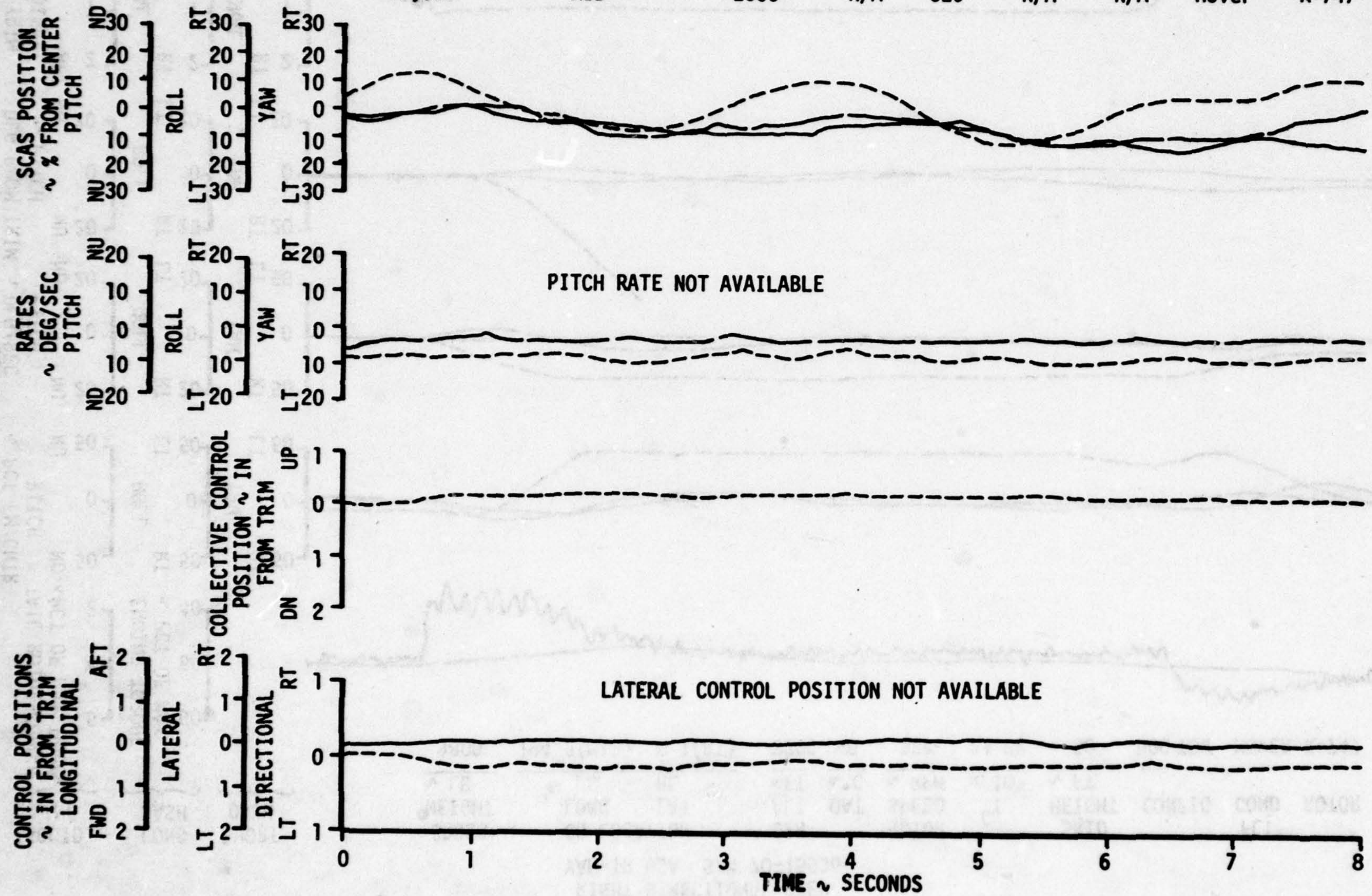


FIGURE 25
SCAS FAILURE
YAH-1R USA S/N 70-15936

| GROSS WEIGHT ~LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~FT | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ x $10^4$ | CONFIG. | FLIGHT COND. |
|---|---|---|---|---|---|---|---|---|
| 9540 | 195.2(MID) | 0.1(RT) | -3320 | -7 | 325 | 42.77 | 8-TOW | Hover |

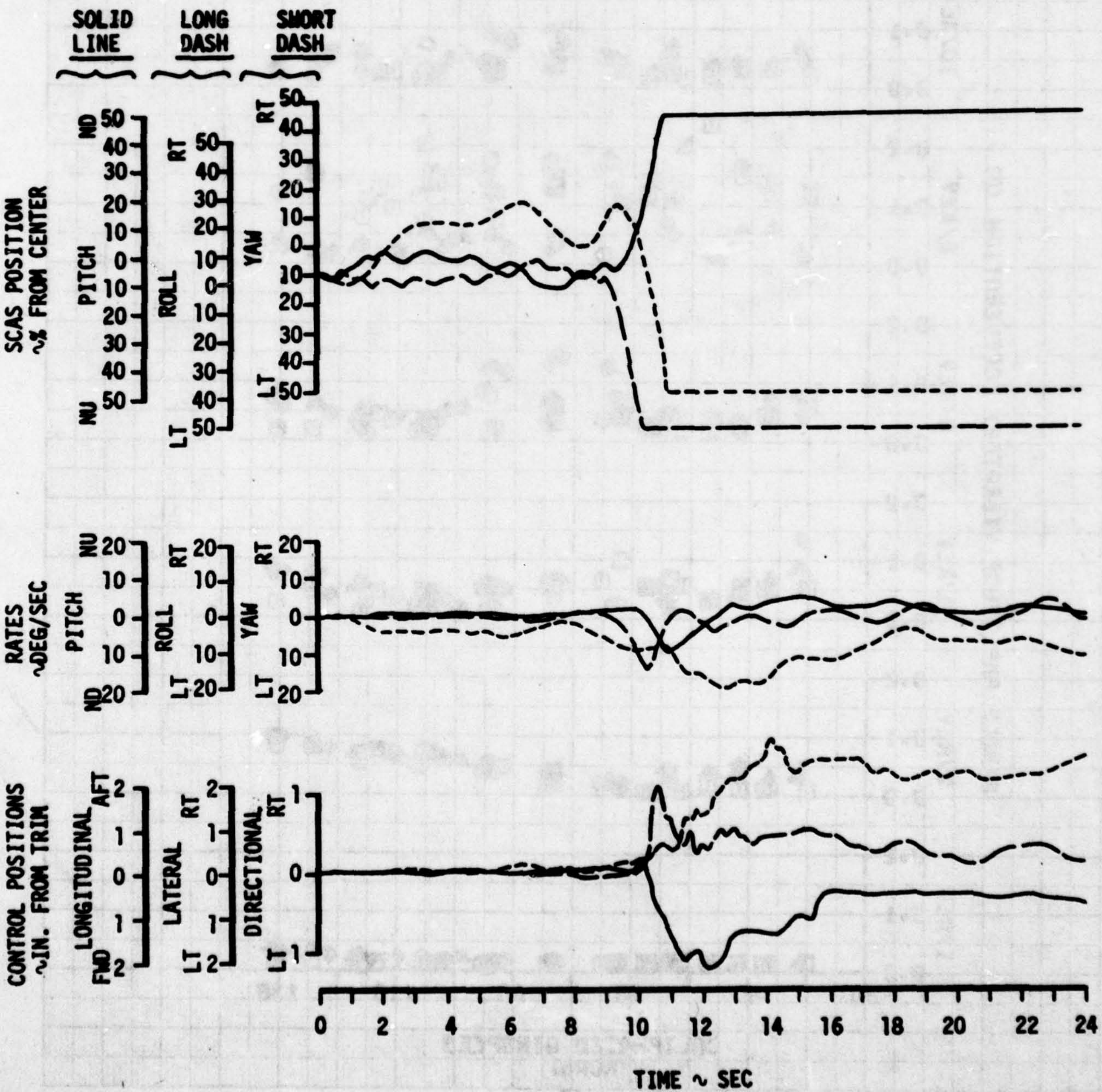


FIGURE 25
LEVEL FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT VERTICAL

| SYM | GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FT | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| ○ | 8590 | 195.7(MID) | 0.1(RT) | 4590 | 8 | 325 | 44.57 | B TOW | B-540 |
| □ | 8940 | 196.1(MID) | 0.1(RT) | 7220 | 4 | 325 | 54.77 | B TOW | B-540 |
| ◇ | 8230 | 195.4(MID) | 0.1(RT) | 5870 | 9 | 325 | 48.41 | B TOW | K-747 |
| △ | 8720 | 195.8(MID) | 0.1(RT) | 7580 | 8 | 325 | 54.11 | B TOW | K-747 |

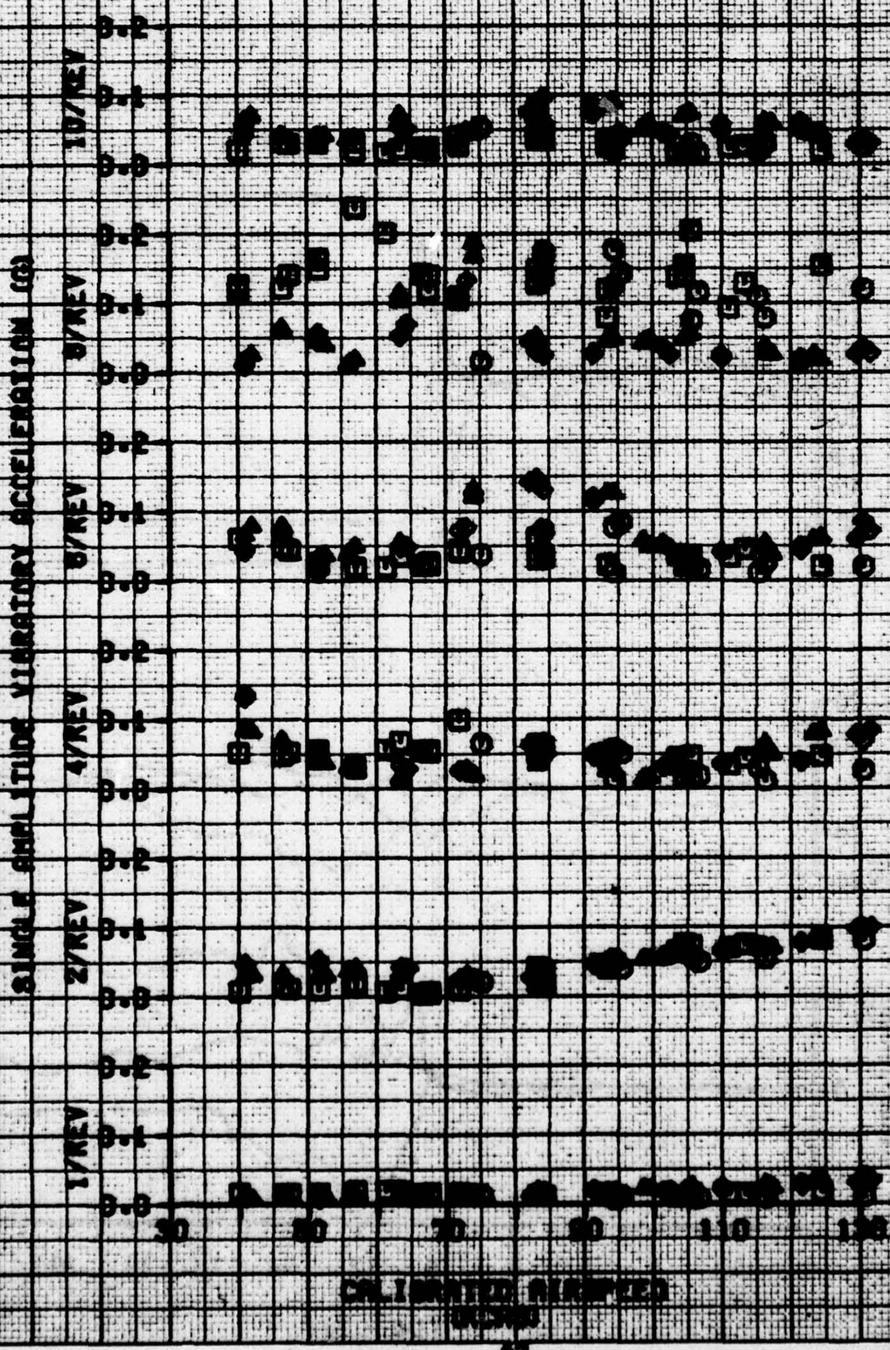


FIGURE 27
[illegible] VIBRATION CHARACTERISTICS
[illegible] USA S/N 70-[illegible]
PILOT LATERAL

| SYM | GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FT | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| ○ | 8590 | 195.7(MID) | 0.1(RT) | 4590 | 8 | 325 | 48.57 | B TOW | B-540 |
| □ | 8940 | 196.1(MID) | 0.1(RT) | 7220 | 4 | 325 | 54.77 | B TOW | B-540 |
| ◇ | 8230 | 195.4(MID) | 0.1(RT) | 5870 | 9 | 325 | 48.41 | B TOW | K-747 |
| △ | 8720 | 195.8(MID) | 0.1(RT) | 7660 | 8 | 325 | 54.11 | B TOW | K-747 |

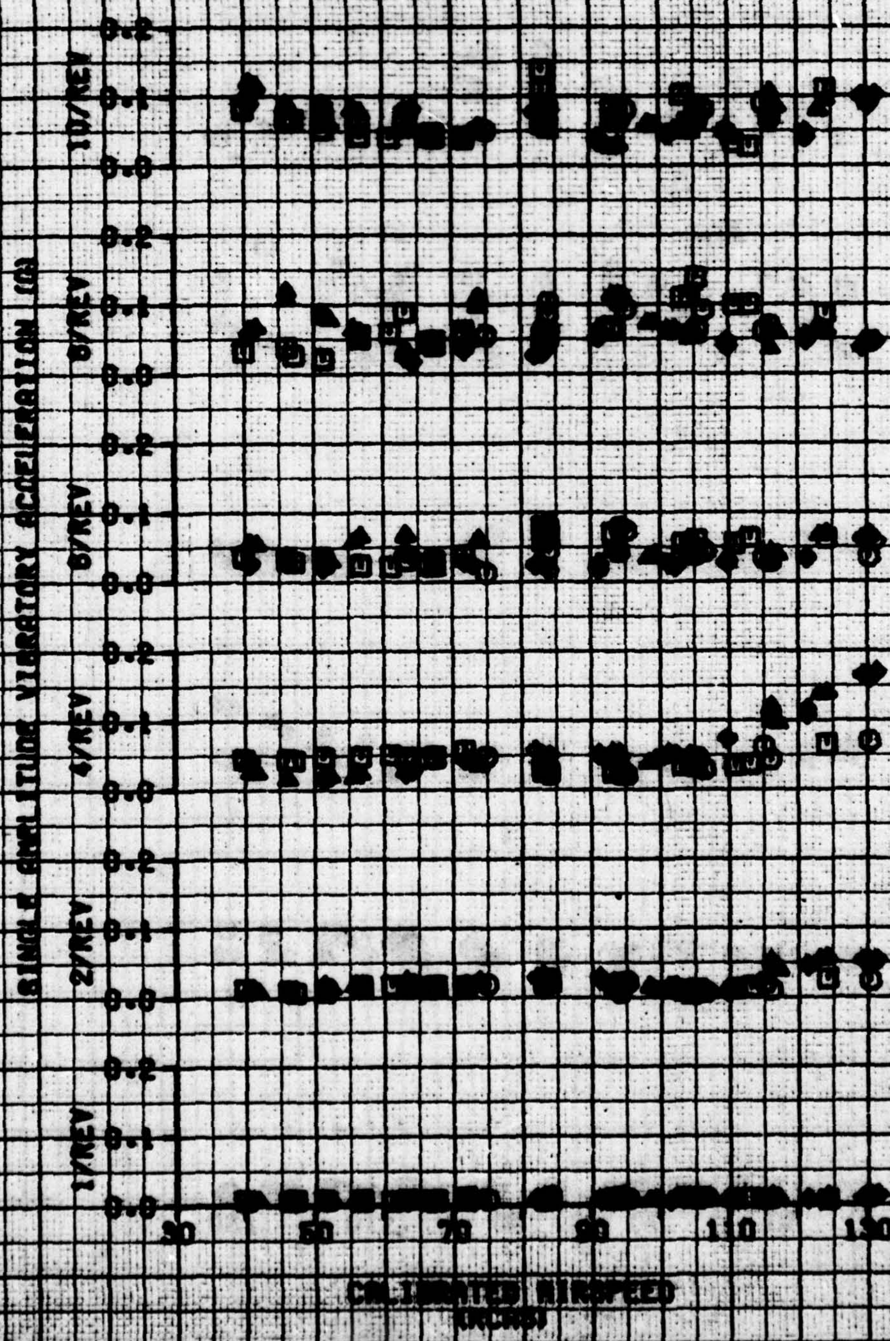


FIGURE 28
LEVEL FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT LONGITUDINAL

| SYM | GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FT | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| ○ | 8590 | 195.7(MID) | 0.1(RT) | 4590 | 8 | 325 | 48.57 | 8 TOW | B-540 |
| □ | 8940 | 196.1(MID) | 0.1(RT) | 7220 | 4 | 325 | 54.77 | 8 TOW | B-540 |
| ◇ | 8230 | 195.4(MID) | 0.1(RT) | 5870 | 9 | 325 | 48.47 | 8 TOW | K-747 |
| △ | 8720 | 195.8(MID) | 0.1(RT) | 7560 | 8 | 325 | 54.11 | 8 TOW | K-747 |

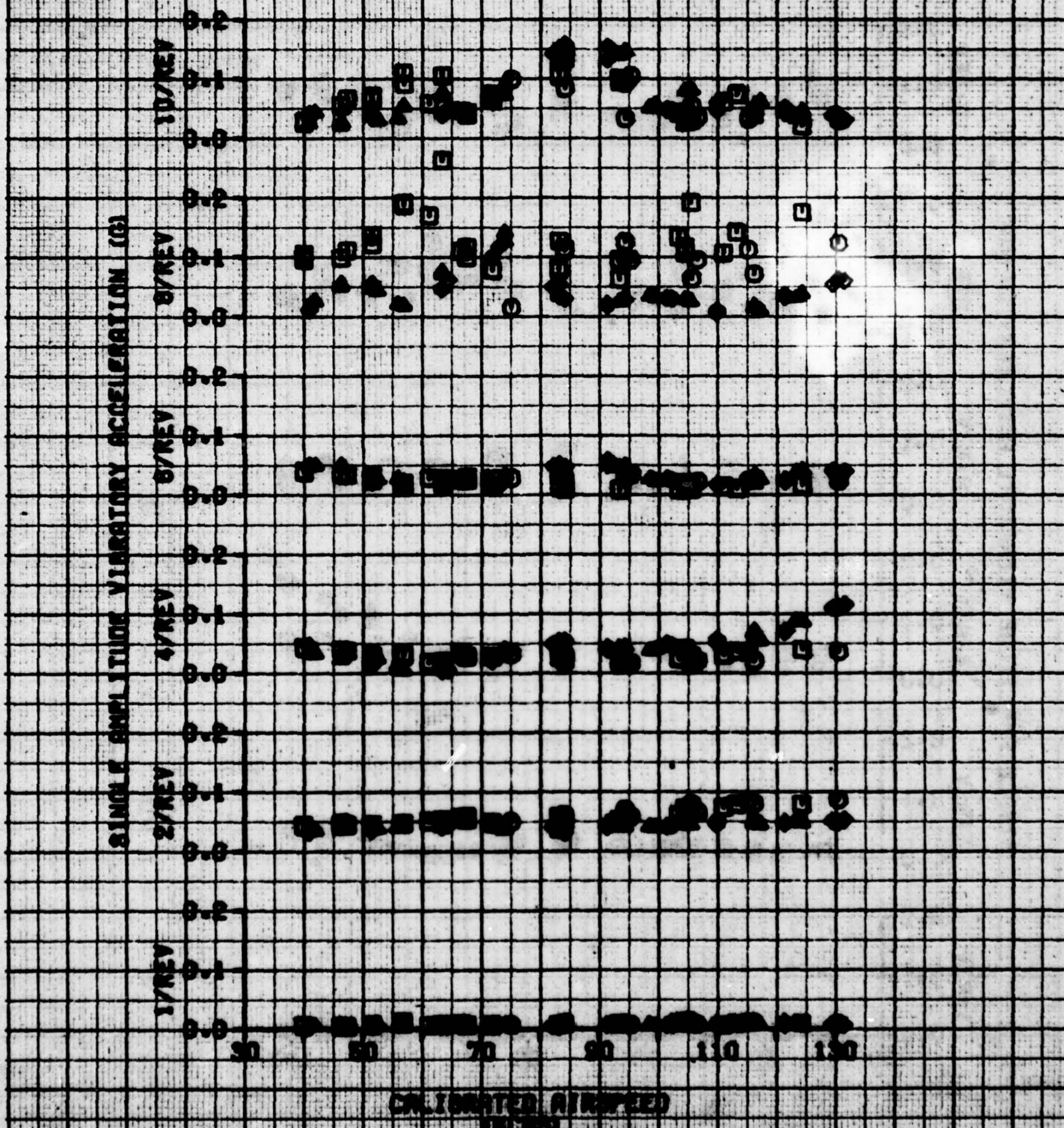


FIGURE 29
LEVEL FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT VERTICAL

| SYM | GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FT | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| ○ | 8590 | 195.7(MID) | 0.1(RT) | 4590 | 8 | 325 | 48.57 | 8 TOW | B-540 |
| □ | 8940 | 196.1(MID) | 0.1(RT) | 7220 | 4 | 325 | 54.77 | 8 TOW | B-540 |
| ◇ | 8230 | 195.4(MID) | 0.1(RT) | 5870 | 9 | 325 | 48.41 | 8 TOW | K-747 |
| △ | 8720 | 195.8(MID) | 0.1(RT) | 7660 | 8 | 325 | 54.11 | 8 TOW | K-747 |

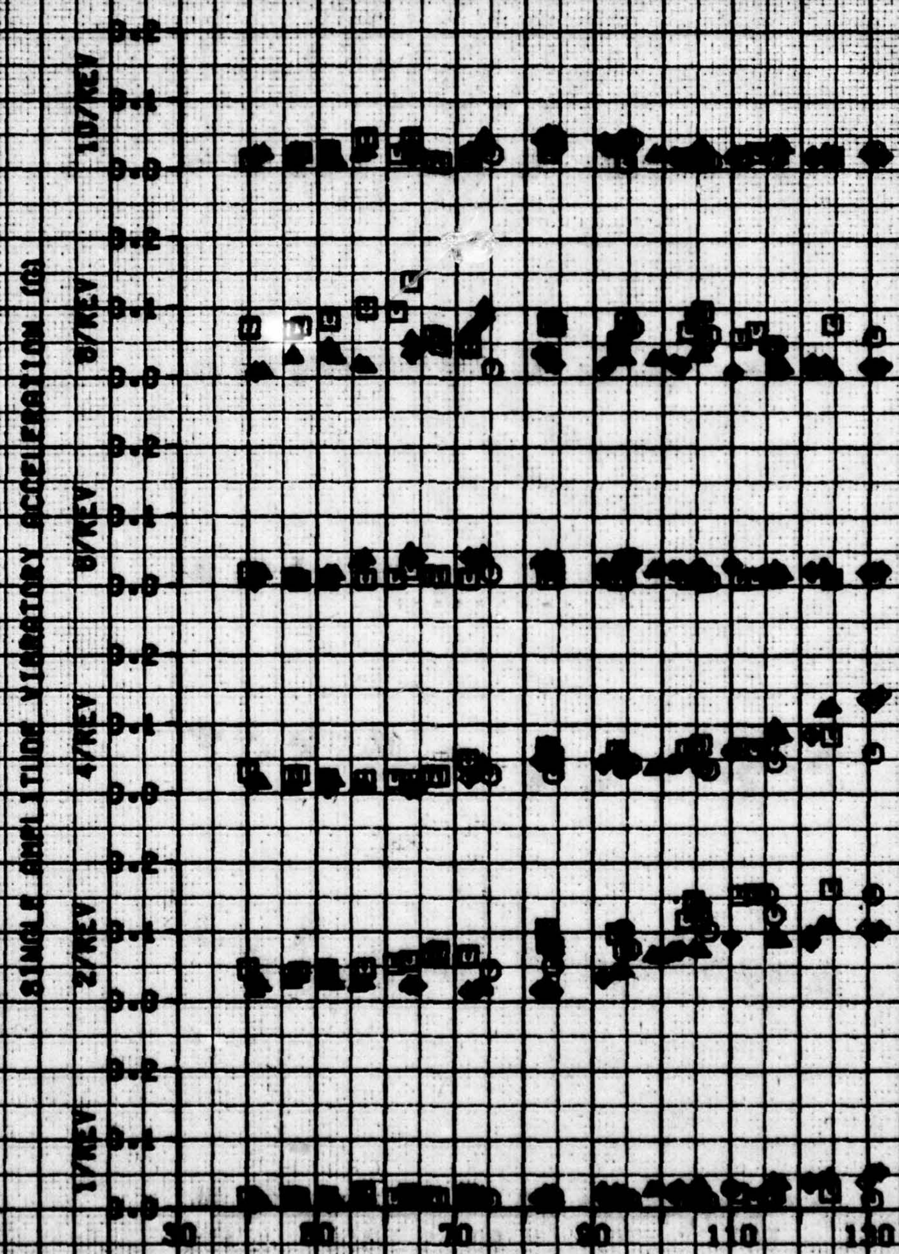


FIGURE 38

LEVEL FLIGHT VIBRATION CHARACTERISTICS

YAH-1R USA S/N 70-15936

CO-PILOT LATERAL

| SYM | GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FT | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| ⦶ | 8590 | 195.7(MID) | 0.1(RT) | 4590 | 8 | 325 | 48.57 | 8 TOW | B-540 |
| ⊞ | 8940 | 196.1(MID) | 0.1(RT) | 7220 | 4 | 325 | 54.77 | 8 TOW | B-540 |
| ◆ | 8230 | 195.4(MID) | 0.1(RT) | 5870 | 9 | 325 | 48.4 | 8 TOW | K-747 |
| ▲ | 8720 | 195.8(MID) | 0.1(RT) | 7660 | 8 | 325 | 54.1 | 8 TOW | K-747 |

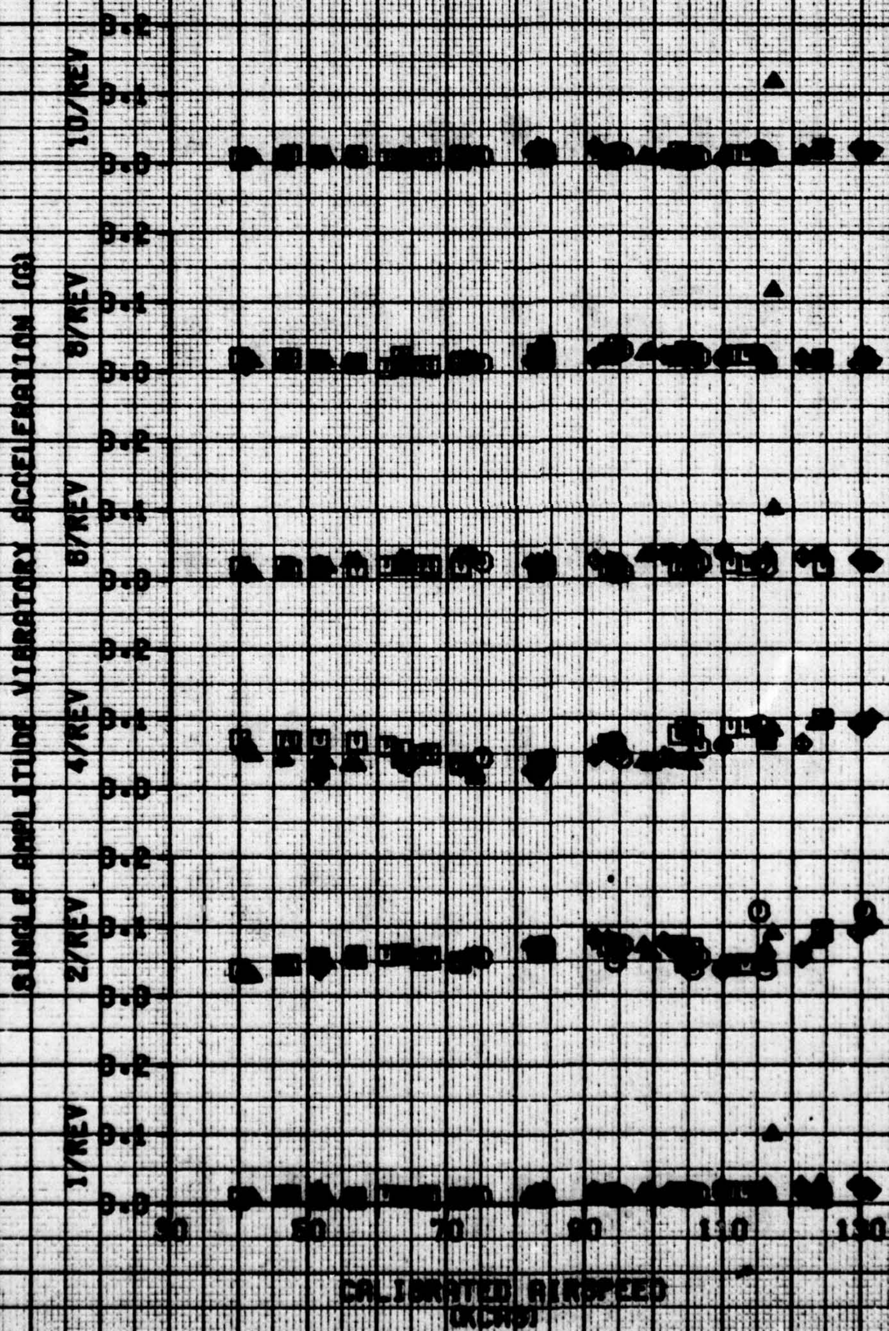
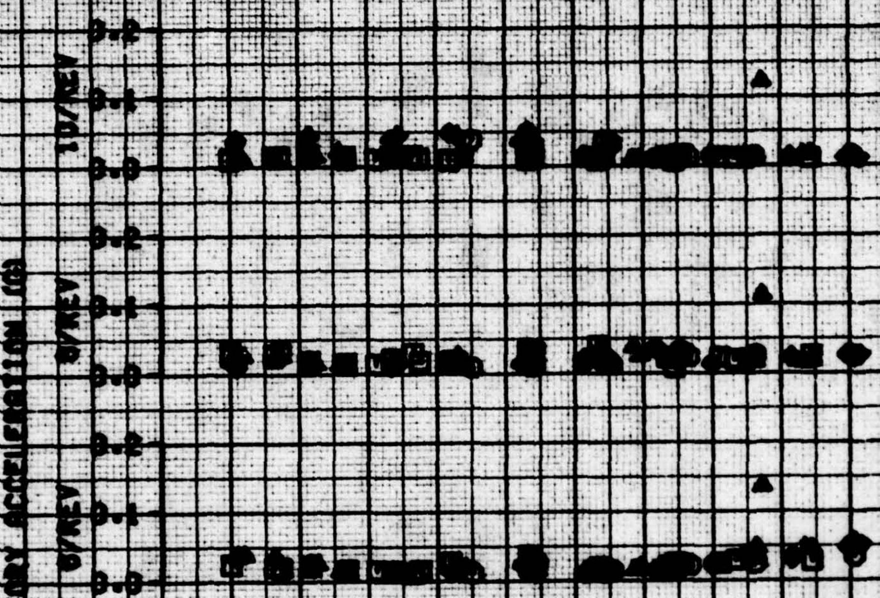


FIGURE 31
LEVEL FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT LONGITUDINAL

| SYM | GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FT | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^5$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| ○ | 8590 | 195.7(MID) | 0.1(RT) | 4590 | 8 | 325 | 48.57 | 8 TOW | B-540 |
| □ | 8940 | 196.1(MID) | 0.1(RT) | 7220 | 4 | 325 | 54.77 | 8 TOW | B-540 |
| ◇ | 8230 | 195.4(MID) | 0.1(RT) | 5870 | 9 | 325 | 48.41 | 8 TOW | K-747 |
| △ | 8720 | 195.8(MID) | 0.1(RT) | 7660 | 8 | 325 | 54.11 | 8 TOW | K-747 |




CALIBRATED AIRSPEED
~KNOTS

FIGURE 32
LEVEL FLIGHT VIBRATION CHARACTERISTICS
CG VERTICAL

| SYM | GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FT | OAT ~ °C | ROTOR SPEED ~ RPM | $C_T \times 10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| ○ | [illegible] | [illegible].7 (MID) | 0.1 (RT) | 4590 | 8 | 325 | 48.57 | 8 TON | [illegible] |
| □ | [illegible] | [illegible].1 (MID) | 0.1 (RT) | 7220 | 4 | 326 | 54.77 | 8 TON | [illegible] |
| ◇ | [illegible] | [illegible].4 (MID) | 0.1 (RT) | 5870 | 9 | 325 | 48.41 | 8 TON | [illegible] |
| △ | [illegible] | [illegible].8 (MID) | 0.1 (RT) | [illegible] | 8 | 325 | 54.11 | 8 TON | [illegible] |

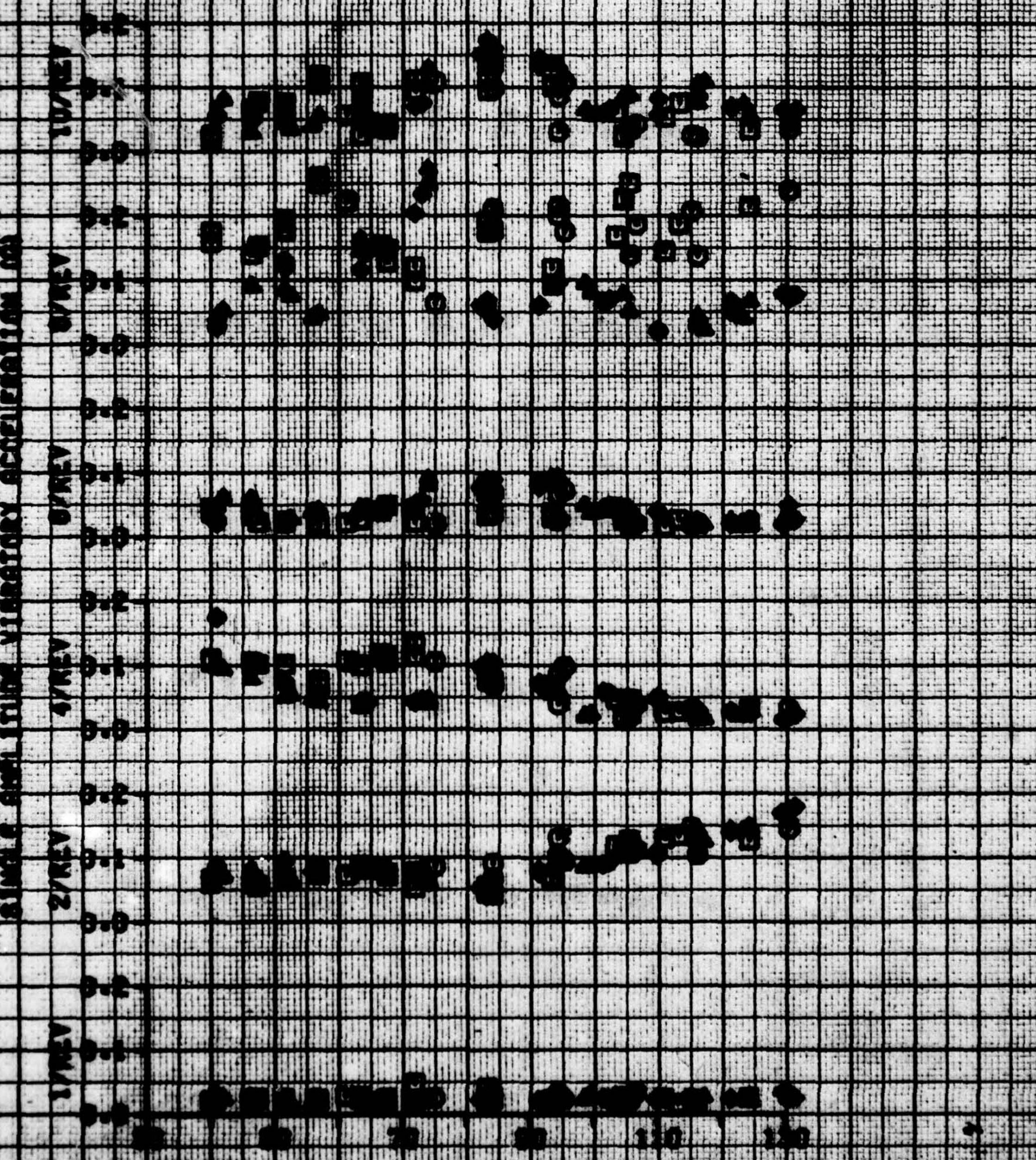


FIGURE 33
LEVEL FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CG LATERAL

| SYM | GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FT | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| ○ | 8590 | 195.7(MID) | 0.1(RT) | 4590 | 8 | 325 | 48.57 | 8 TOW | B-540 |
| □ | 8940 | 196.1(MID) | 0.1(RT) | 7220 | 4 | 325 | 54.77 | 8 TOW | B-540 |
| ◇ | 8230 | 195.4(MID) | 0.1(RT) | 5870 | 9 | 325 | 48.41 | 8 TOW | K-747 |
| △ | 8720 | 195.8(MID) | 0.1(RT) | 7560 | 8 | 325 | 54.11 | 8 TOW | K-747 |

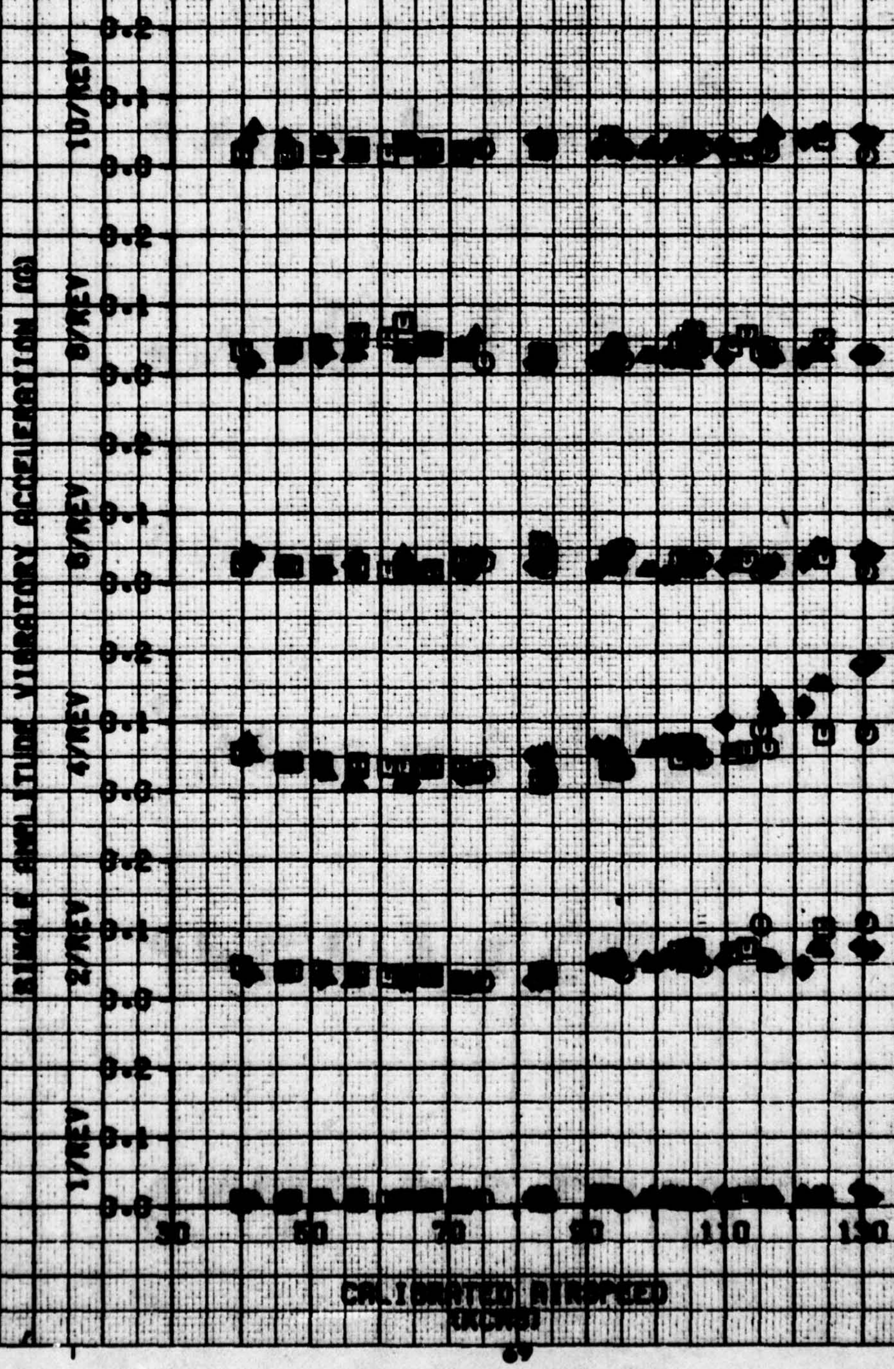


FIGURE 34
LEVEL FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CG LONGITUDINAL

| SYM | GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FT | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ x $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| ○ | 8590 | 195.7(MID) | 0.1(RT) | 4590 | 8 | 325 | 48.57 | 8 TOW | B-540 |
| □ | 8940 | 196.1(MID) | 0.1(RT) | 7220 | 4 | 325 | 54.77 | 8 TOW | B-540 |
| ◇ | 8230 | 195.4(MID) | 0.1(RT) | 5870 | 9 | 325 | 48.41 | 8 TOW | K-747 |
| △ | 8720 | 195.8(MID) | 0.1(RT) | 7660 | 8 | 325 | 54.11 | 8 TOW | K-747 |

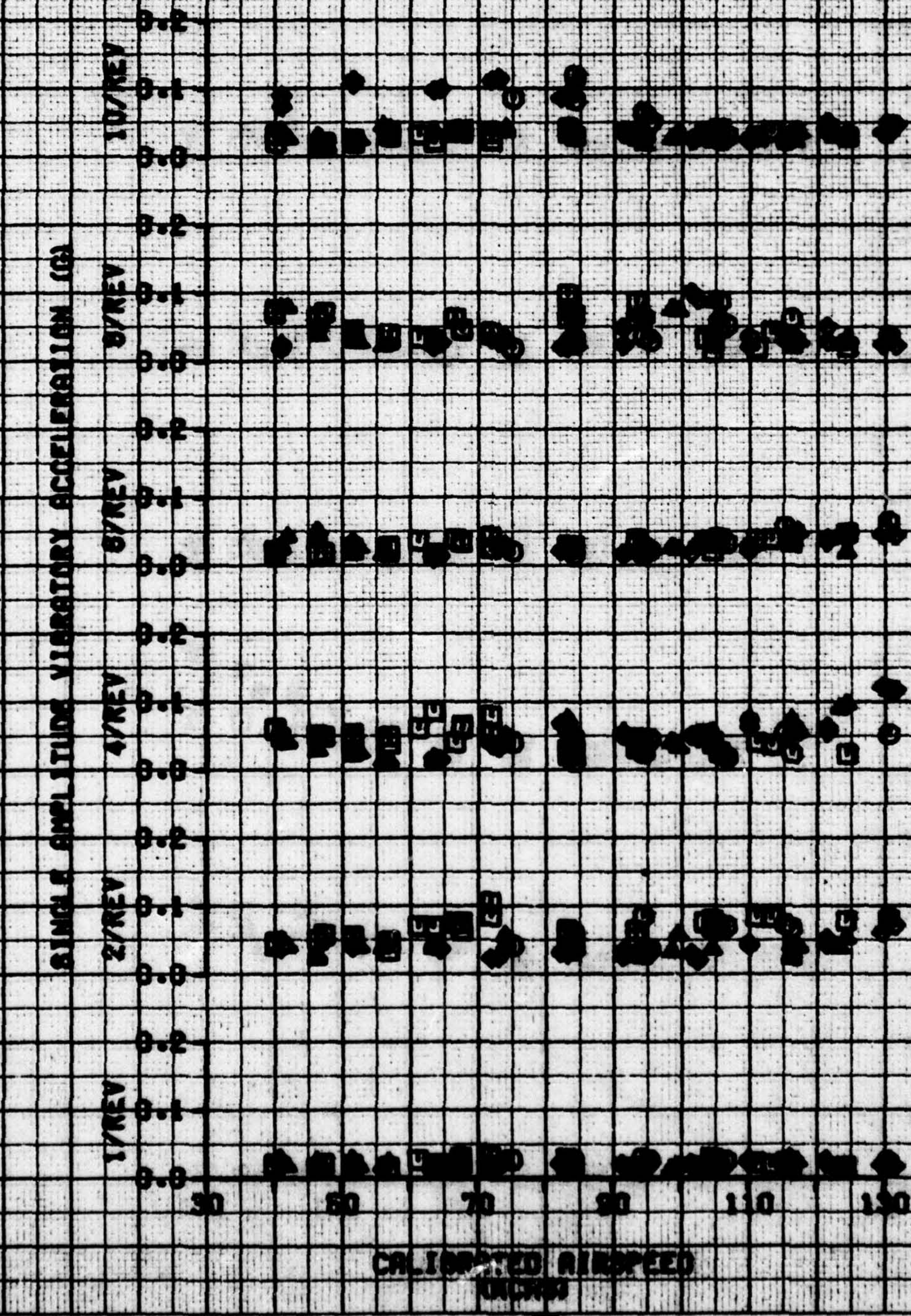


FIGURE 35
HOVER VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT VERTICAL

| CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | MAX WINDS ~KTAS | SKID HEIGHT ~ FT | ROTOR |
|---|---|---|---|---|---|---|
| 196.5(MID) | 0.1(RT) | -3040 | -8 | 2 | 100 | [illegible] |

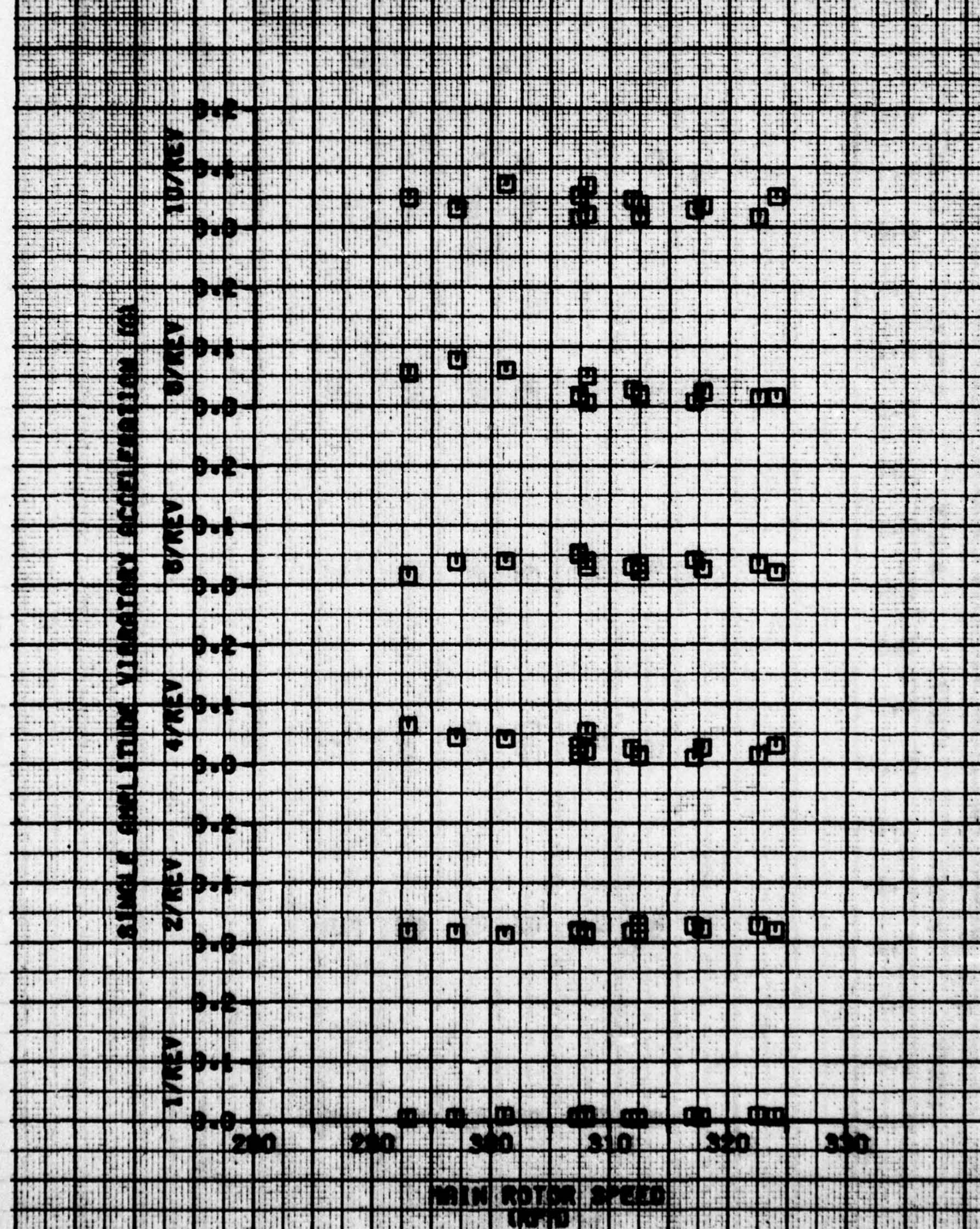


FIGURE 36
HOVER VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT LATERAL

| CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~FEET | OAT ~°C | MAX WINDS ~KTAS | SKID HEIGHT ~FT | ROTOR |
|---|---|---|---|---|---|---|
| 196.5(MID) | 0.1(RT) | -3040 | -8 | 2 | 100 | K-747 |

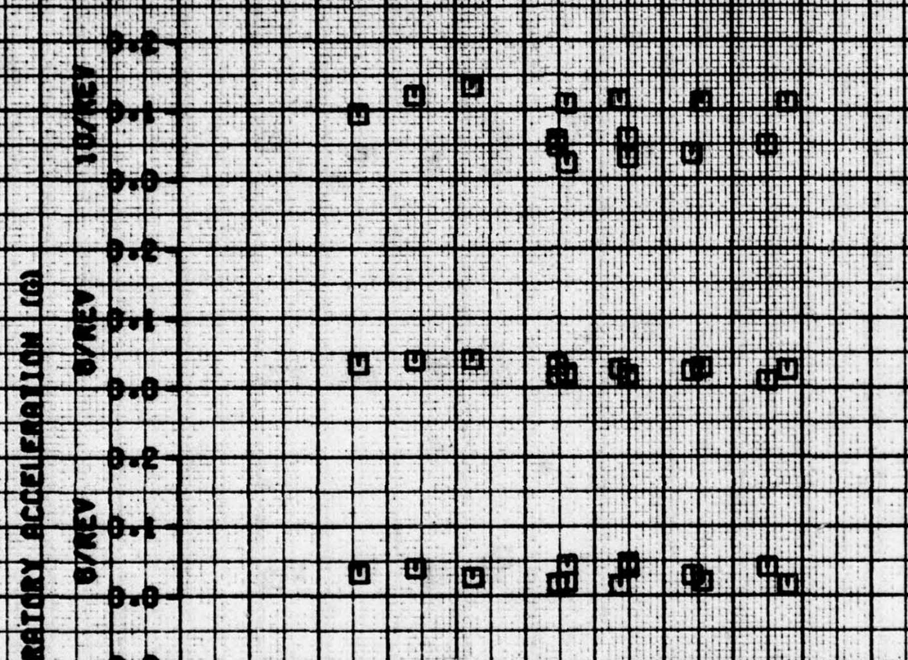


FIGURE 37
HOVER VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT LONGITUDINAL

| CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | MAX WINDS ~KTAS | SKID HEIGHT ~ FT | ROTOR |
|---|---|---|---|---|---|---|
| 196.5(MID) | 0.1(RT) | -3040 | +8 | 2 | 100 | K-747 |

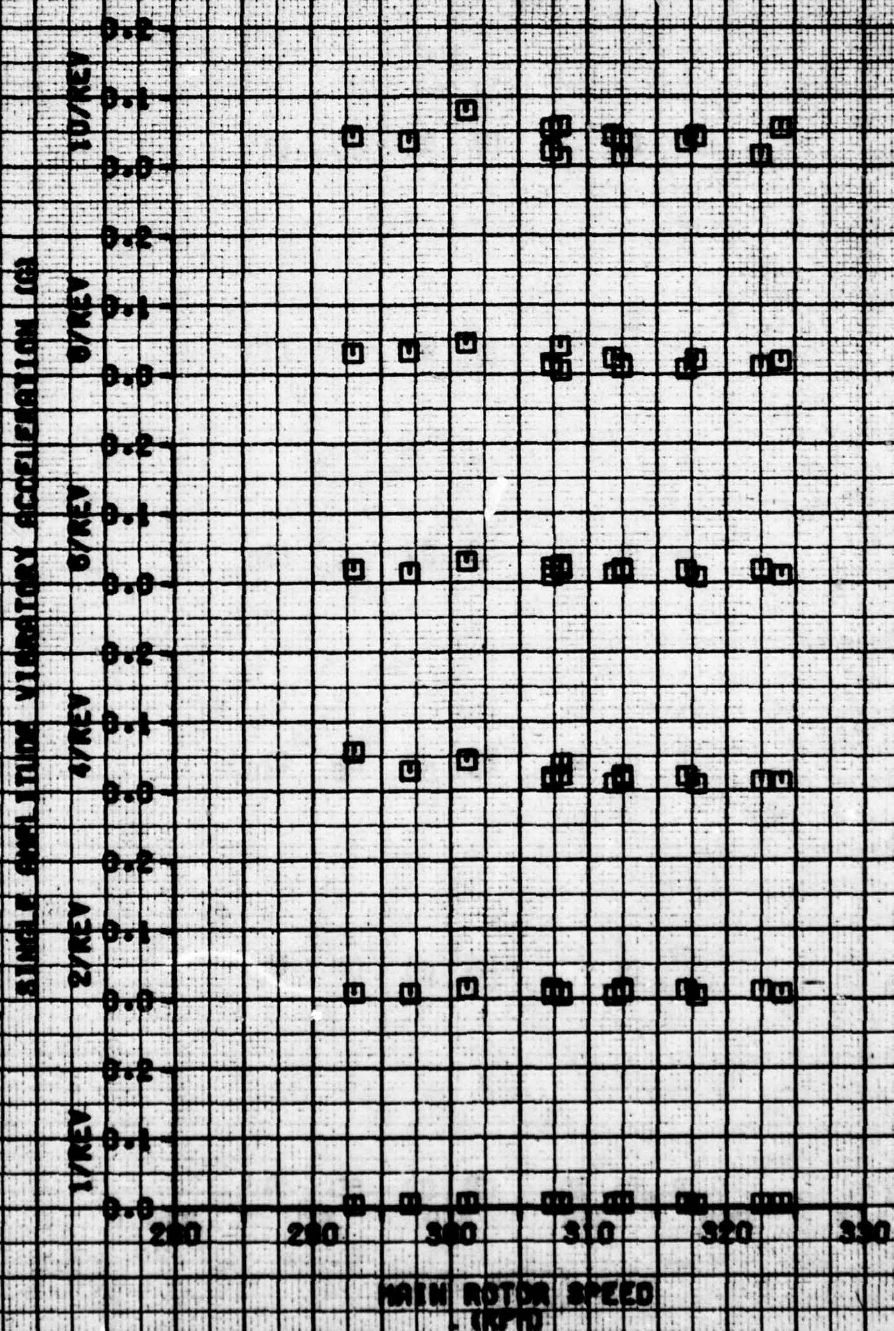


FIGURE 38
HOVER VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT VERTICAL

| CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~ °C | MAX WINDS ~ KTAS | SKID HEIGHT ~ FT | ROTOR |
|---|---|---|---|---|---|---|
| 196.5(MID) | 0.1(RT) | -3040 | -8 | 2 | 100 | K-747 |

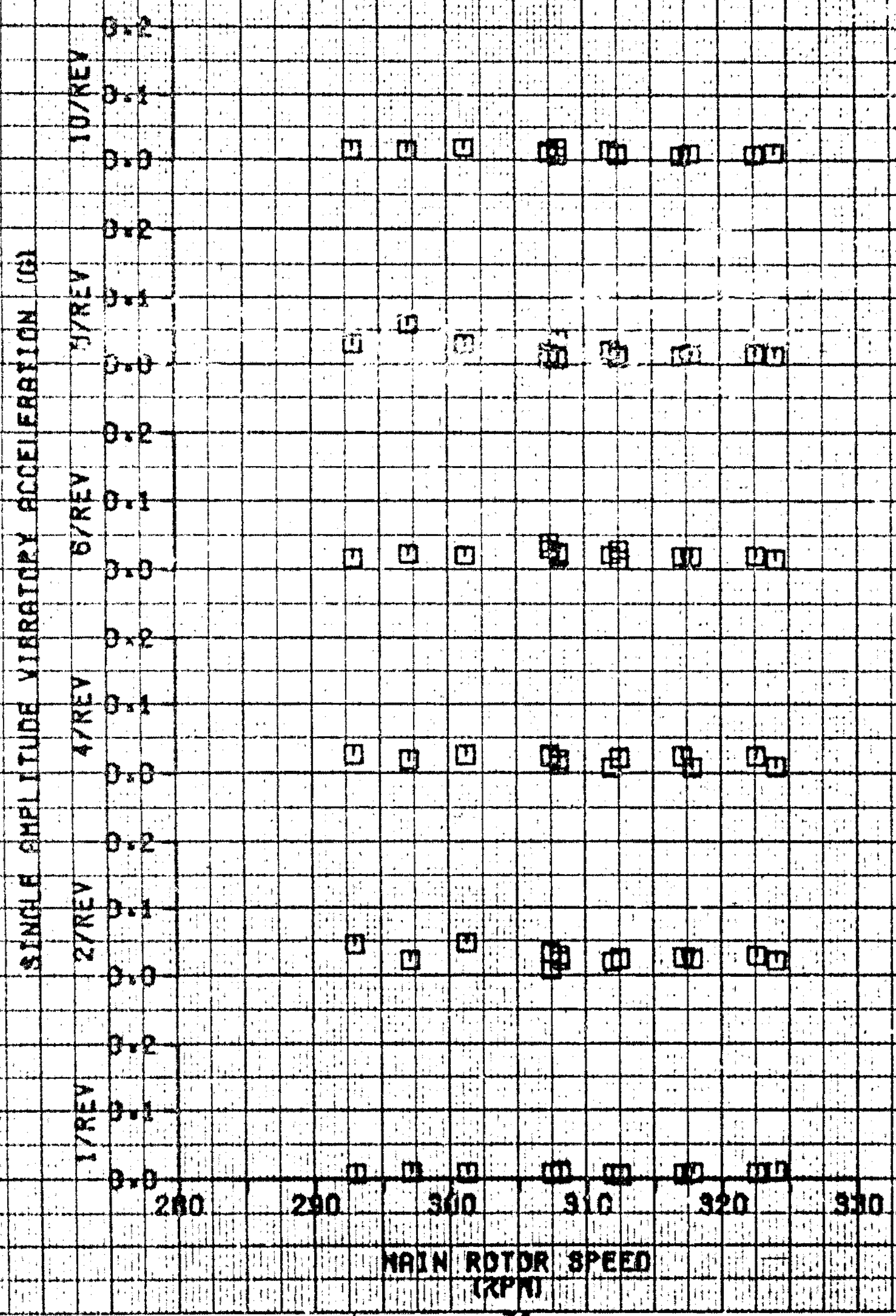





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FIGURE 39
HOVER VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT LATERAL

| CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | MAX WINDS ~KTAS | SKID HEIGHT ~ FT | ROTOR |
|---|---|---|---|---|---|---|
| 196.5(MID) | 0.1(RT) | -3040 | -8 | 2 | 100 | K-747 |

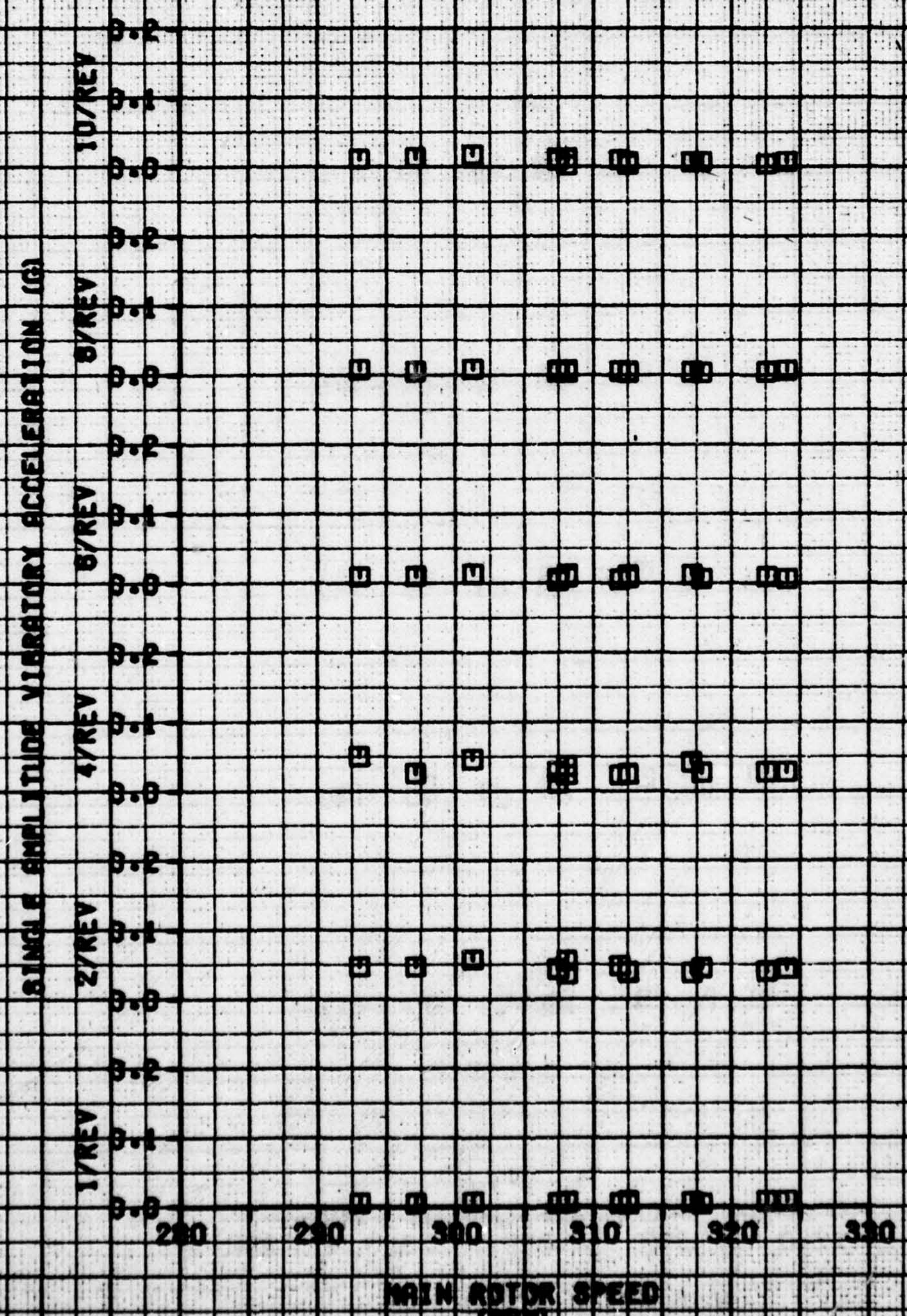


FIGURE 40
HOVER VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT LONGITUDINAL

| CG LOCATION LONG FS | LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | MAX WINDS ~KTAS | SKID HEIGHT ~ FT | ROTOR |
|---|---|---|---|---|---|---|
| 195.5(MID) | 0.1(RT) | -3040 | -8 | 2 | 100 | K-747 |

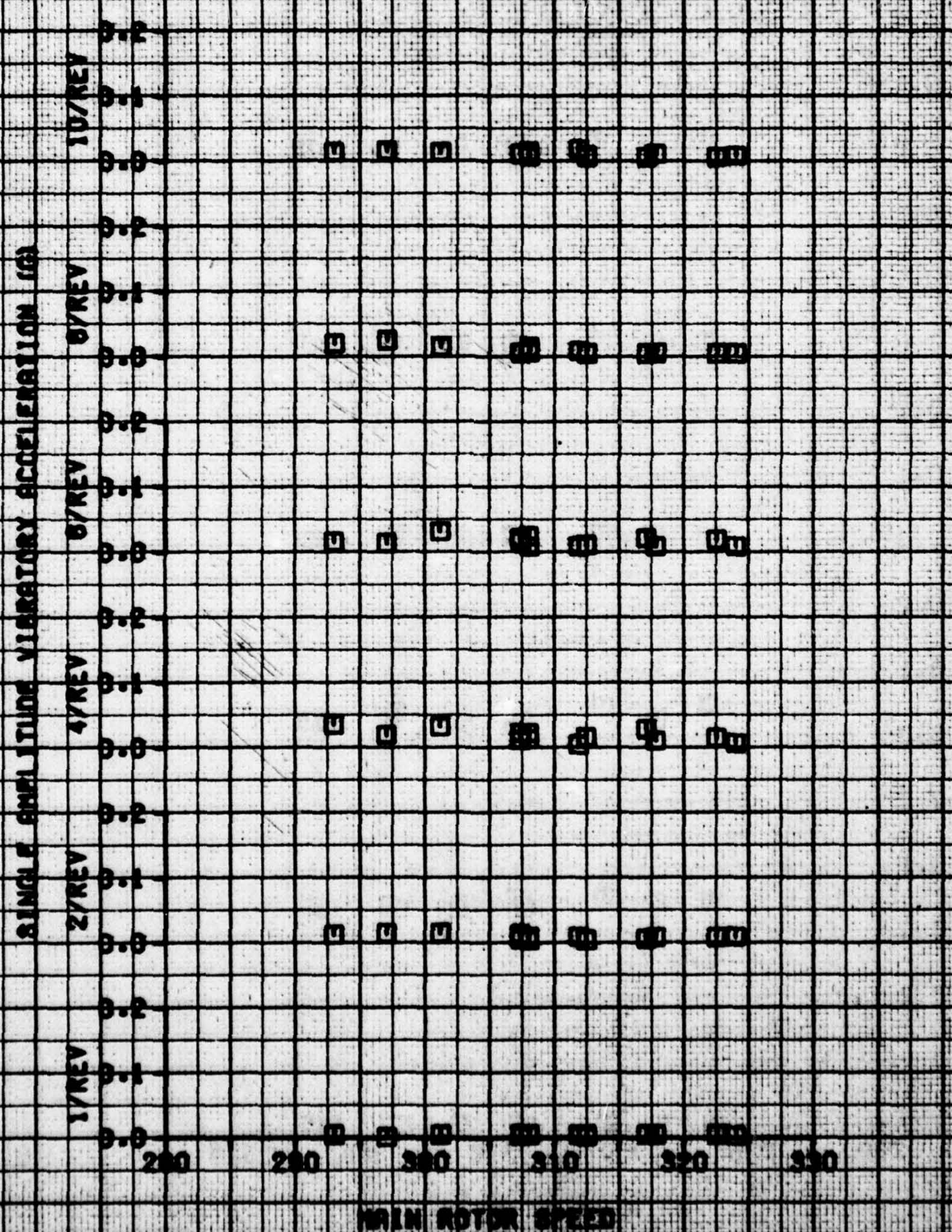


FIGURE 41
HOVER VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CG VERTICAL

| CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | MAX WINDS ~KTAS | SKID HEIGHT ~ FT | ROTOR |
|---|---|---|---|---|---|---|
| 196.5(MID) | 0.1(RT) | -3040 | -8 | 2 | 100 | K-747 |

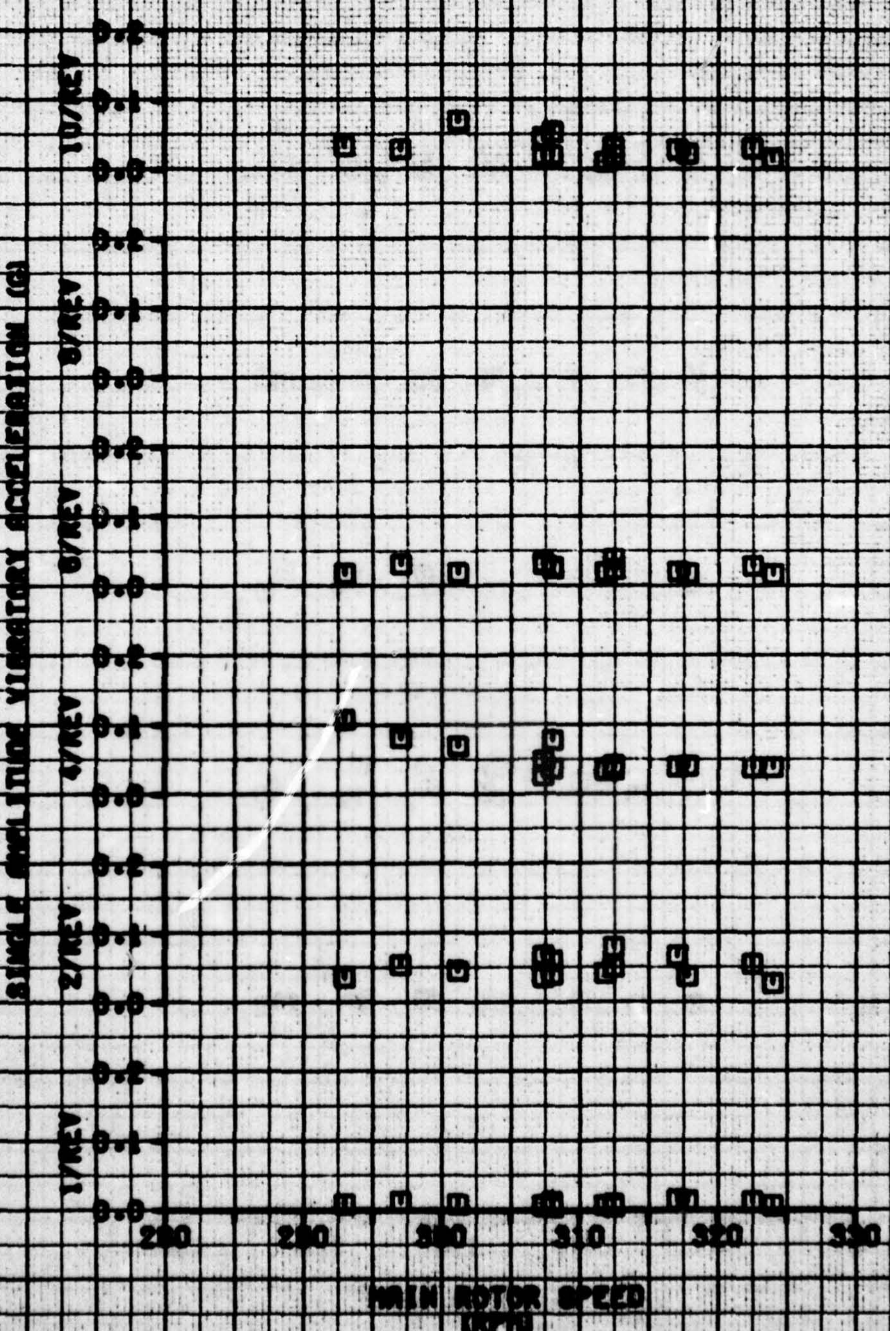


FIGURE 42
HOVER VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CG LATERAL

| CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | MAX WINDS ~KTAS | SKID HEIGHT ~ FT | ROTOR |
|---|---|---|---|---|---|---|
| 196.5(MID) | 0.1(RT) | -3040 | -8 | 2 | 100 | K-747 |

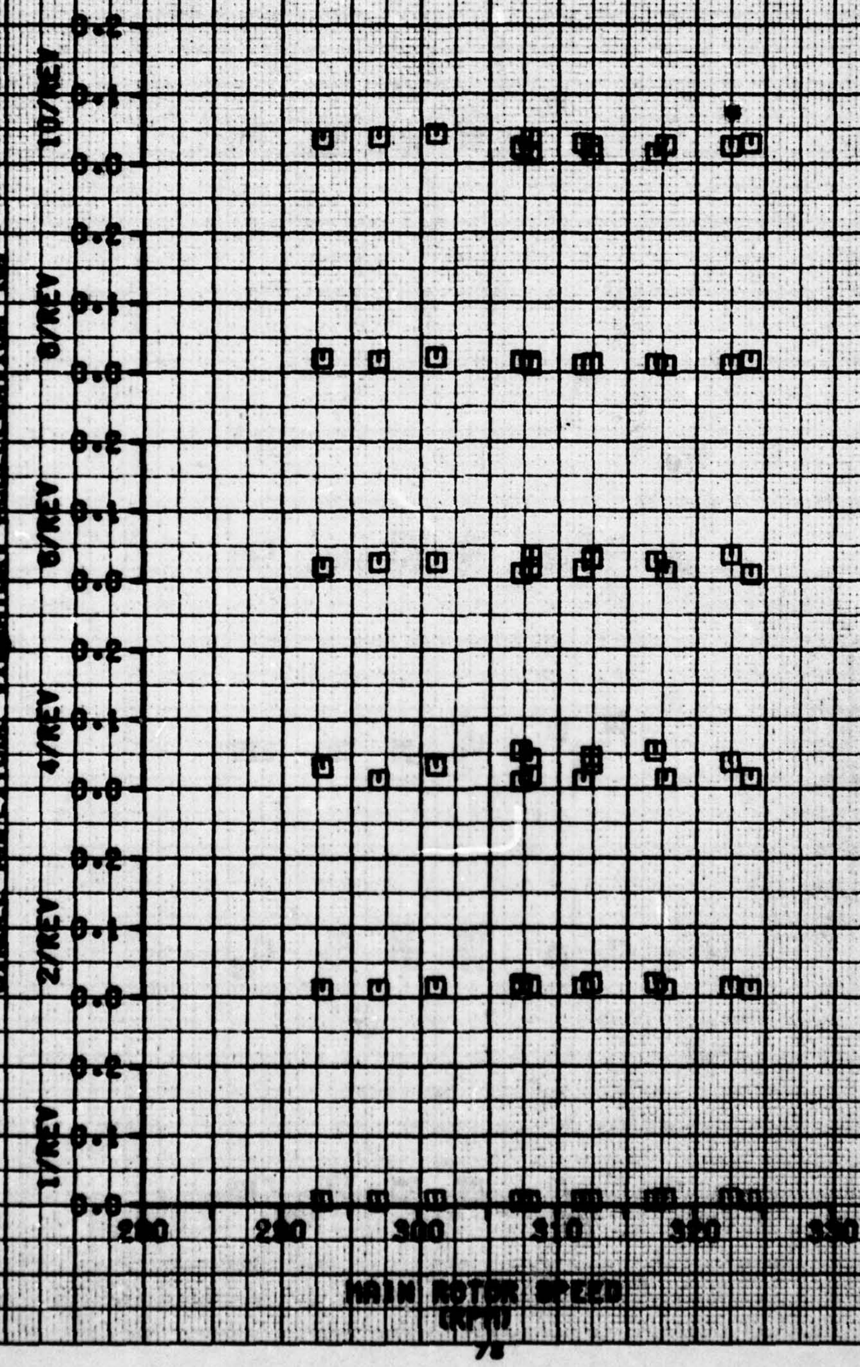


FIGURE 43
HOVER VIBRATION CHARACTERISTICS
[illegible] USA S/N [illegible]
CG LONGITUDINAL

| CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | MAX WINDS ~KTAS | SKID HEIGHT ~ FT | ROTOR |
|---|---|---|---|---|---|---|
| 1[illegible]6.5(MID) | 0.[illegible](RT) | -3040 | -8 | 2 | [illegible] | K-747 |

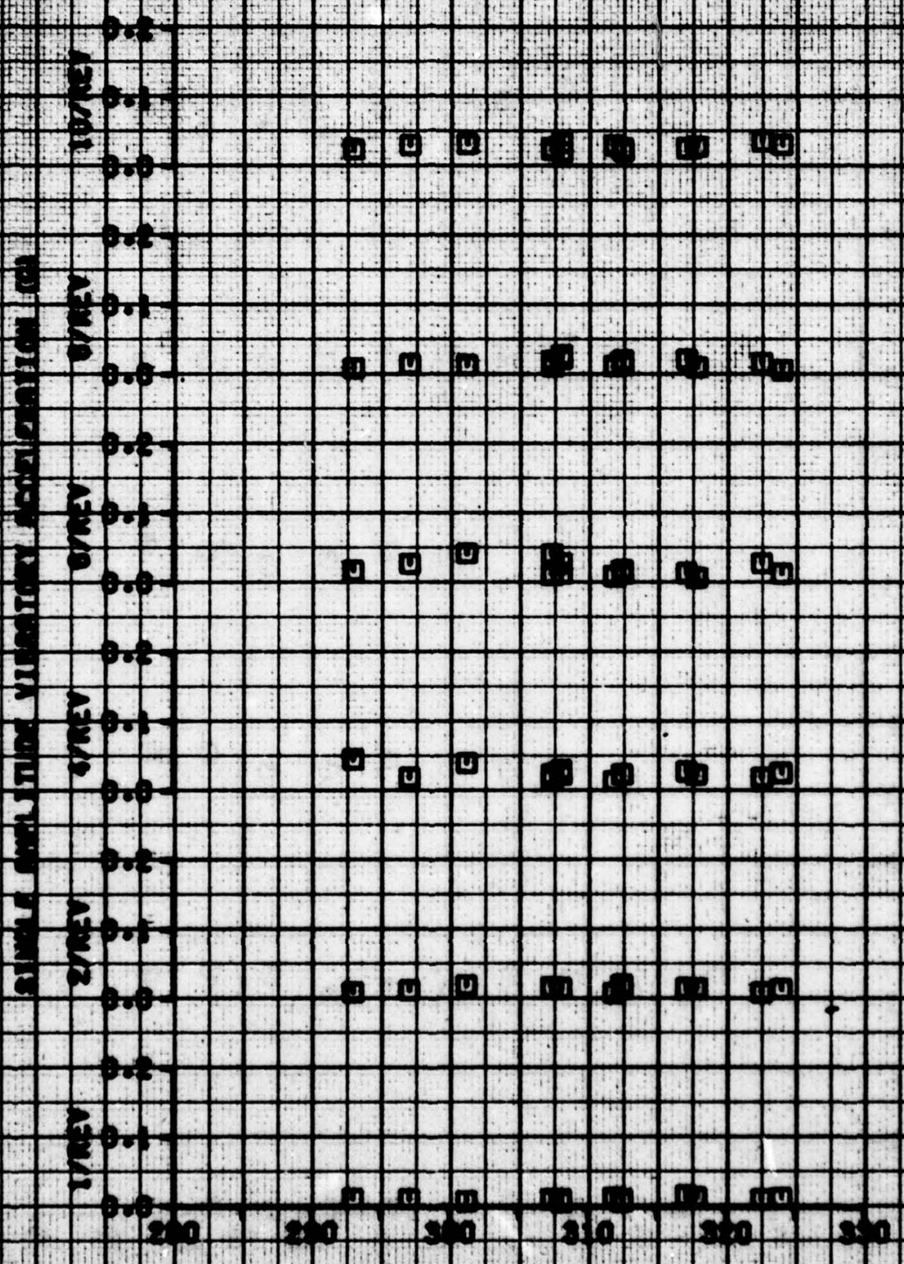


FIGURE 44
SIDEWARD FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT VERTICAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENSITY ALTITUDE ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ $\times 10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|
| 9540 | 195.2(MID) | 0.1(RT) | -3320 | -7 | 325 | 42.77 | 8 TOW | K-747 |

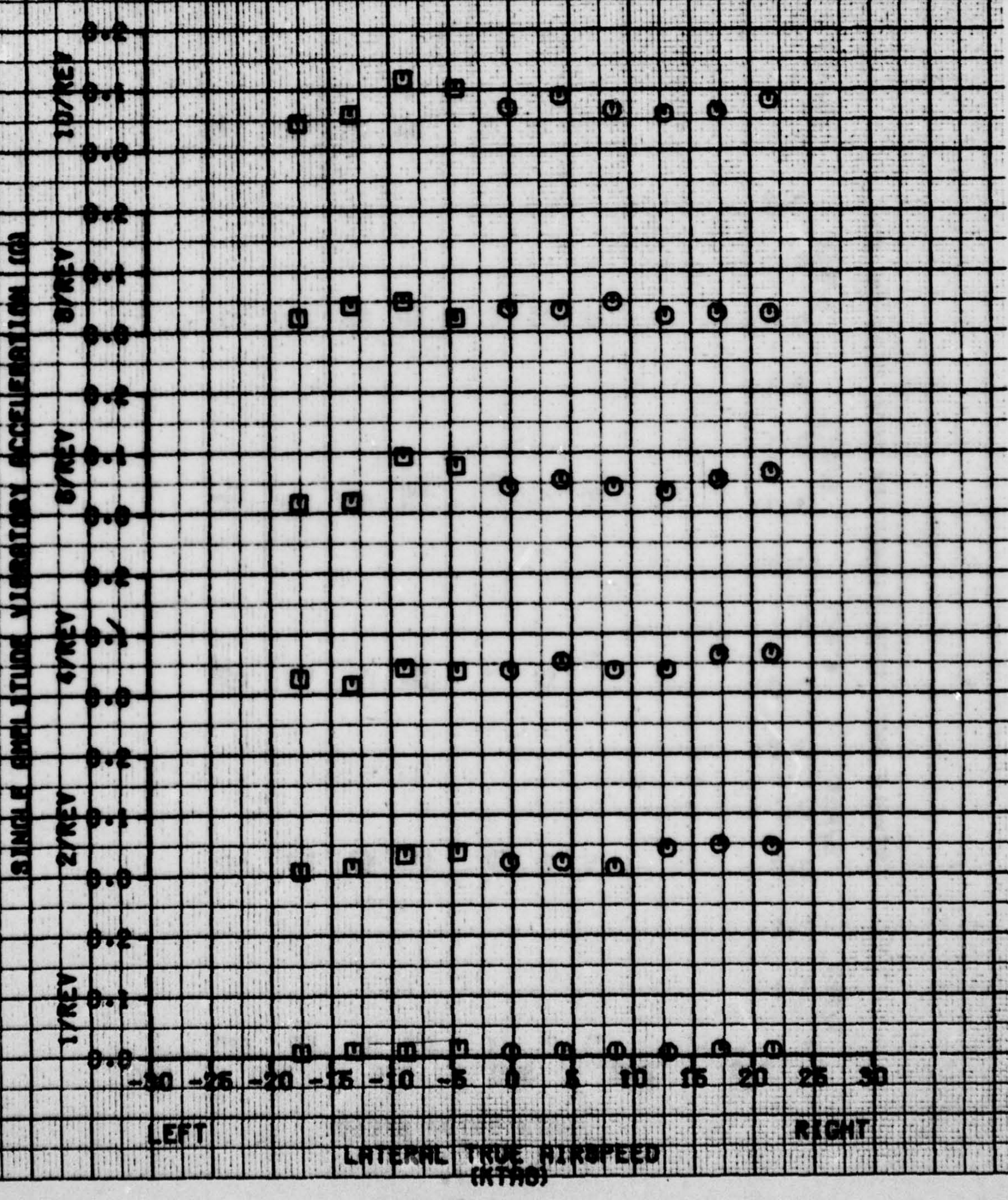


FIGURE 45
SIDEWARD FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT LONGITUDINAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENSITY ALTITUDE ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|
| 9540 | 195.2(MID) | 0.1(RT) | -8320 | -7 | 325 | 42.77 | 8 TOW | K-747 |

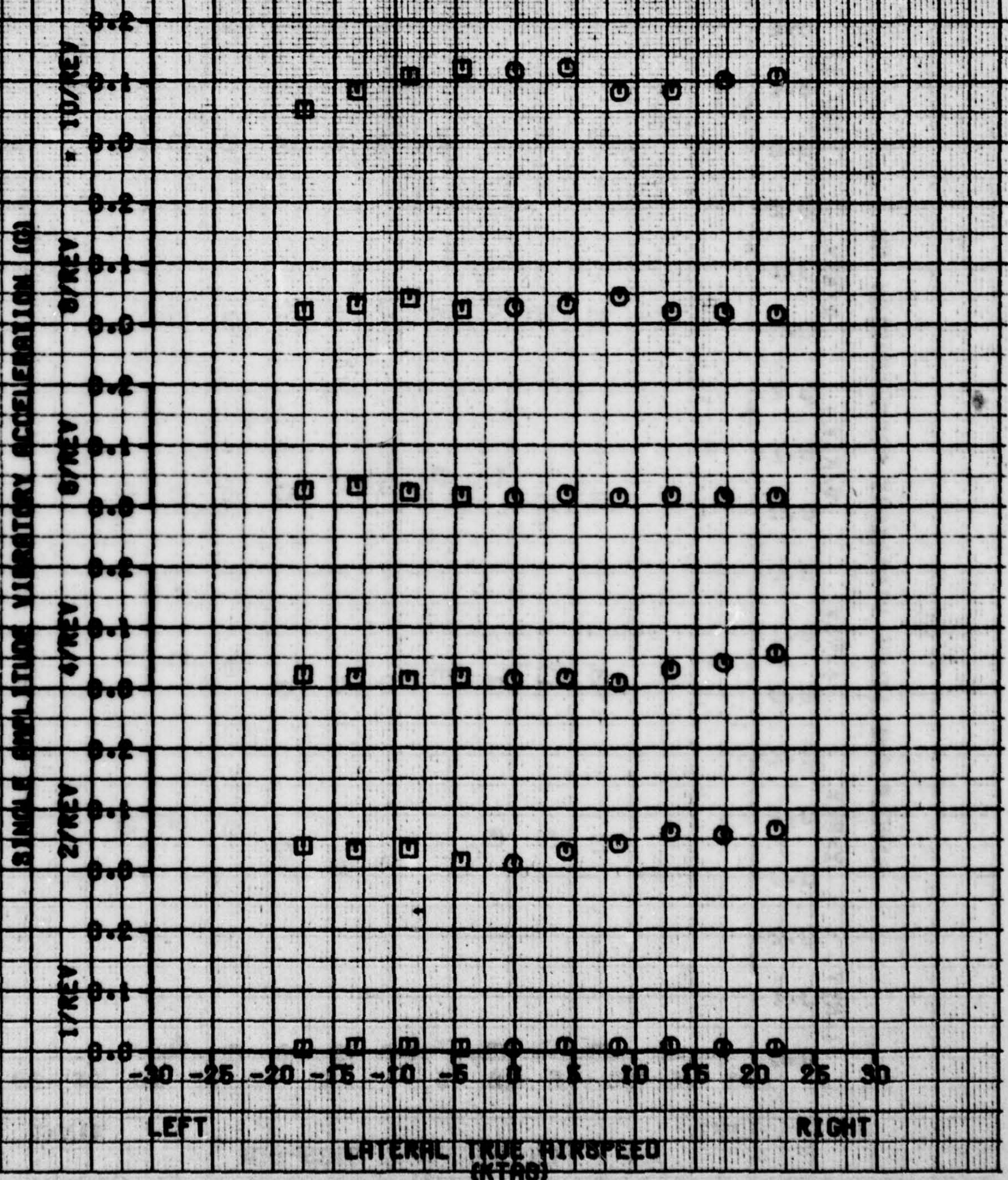


FIGURE 45
SIDEWARD FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT VERTICAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENSITY ALTITUDE ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|
| 9540 | 195.2(MID) | 0.1(RT) | -3320 | -7 | 325 | 42.77 | 8 TOW | X-747 |

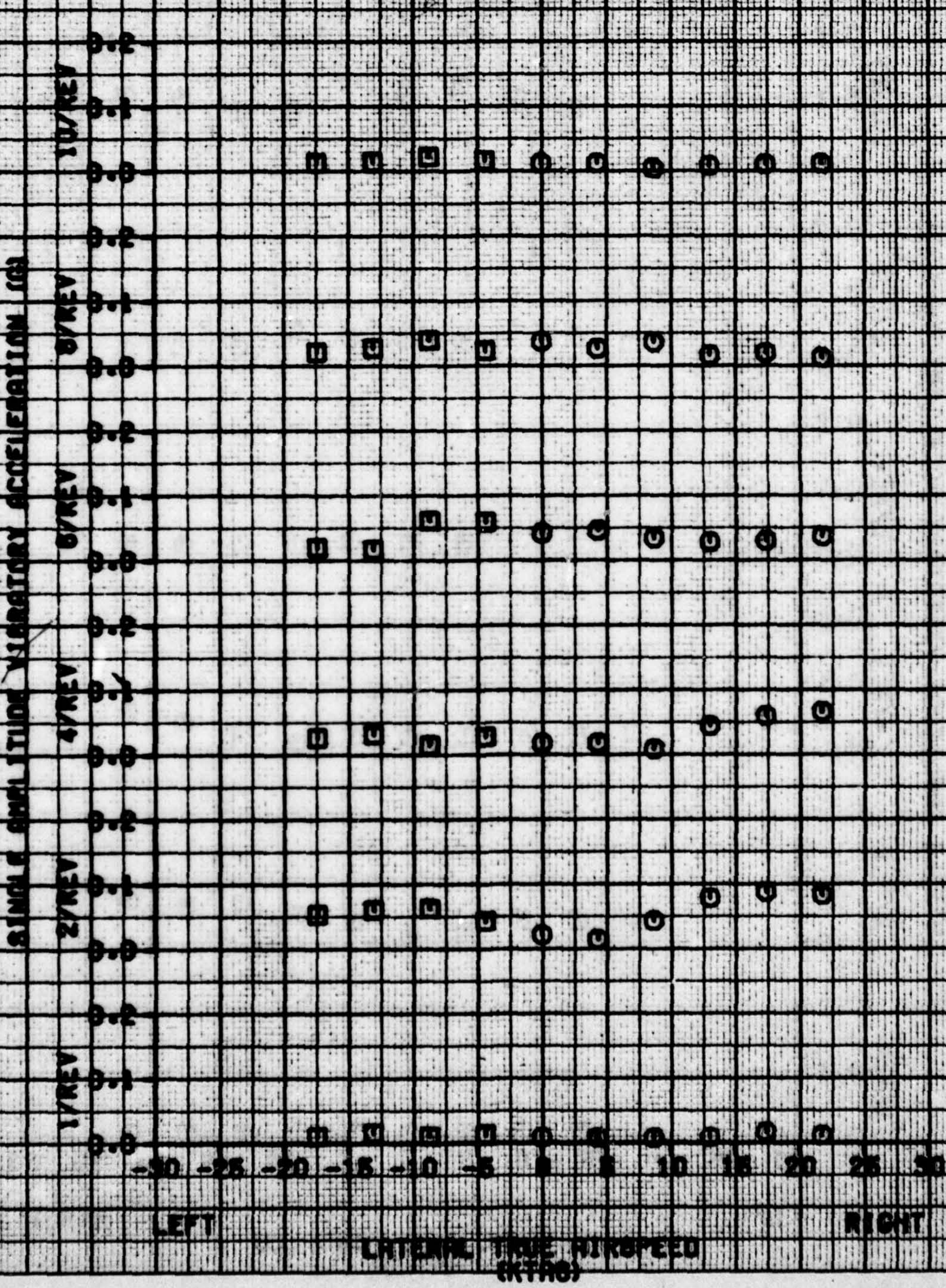


FIGURE 47
SIDEWARD FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT LATERAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENSITY ALTITUDE ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|
| 9540 | 195.2(MID) | 0.1(RT) | -3320 | -7 | 325 | 42.77 | 8 TOW | K-747 |

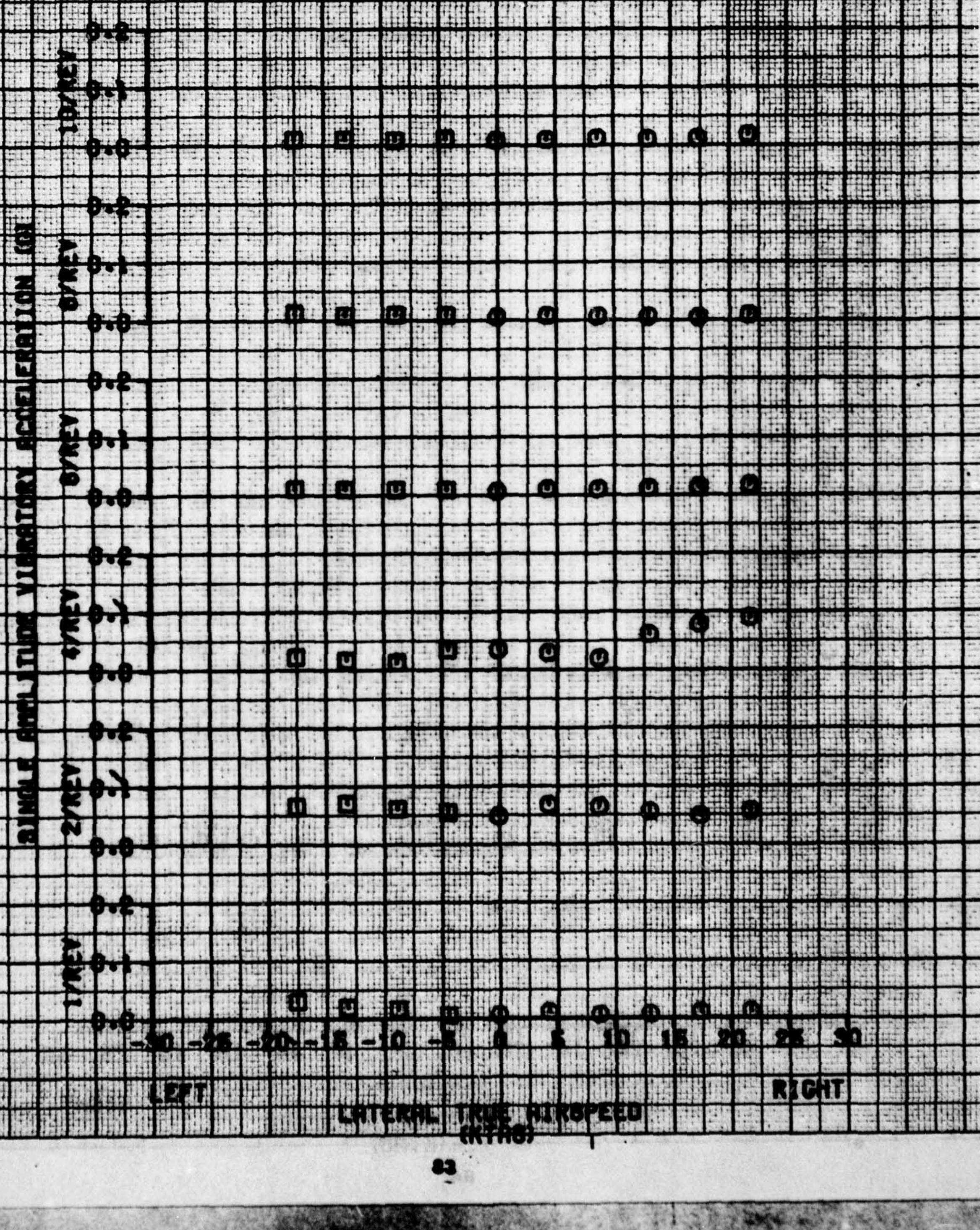


FIGURE 48
SIDEWARD FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT LONGITUDINAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENSITY ALTITUDE ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|
| 9540 | 195.2(MID) | 0.1(RT) | -3320 | -7 | 325 | 42.77 | 8 TOW | K-747 |

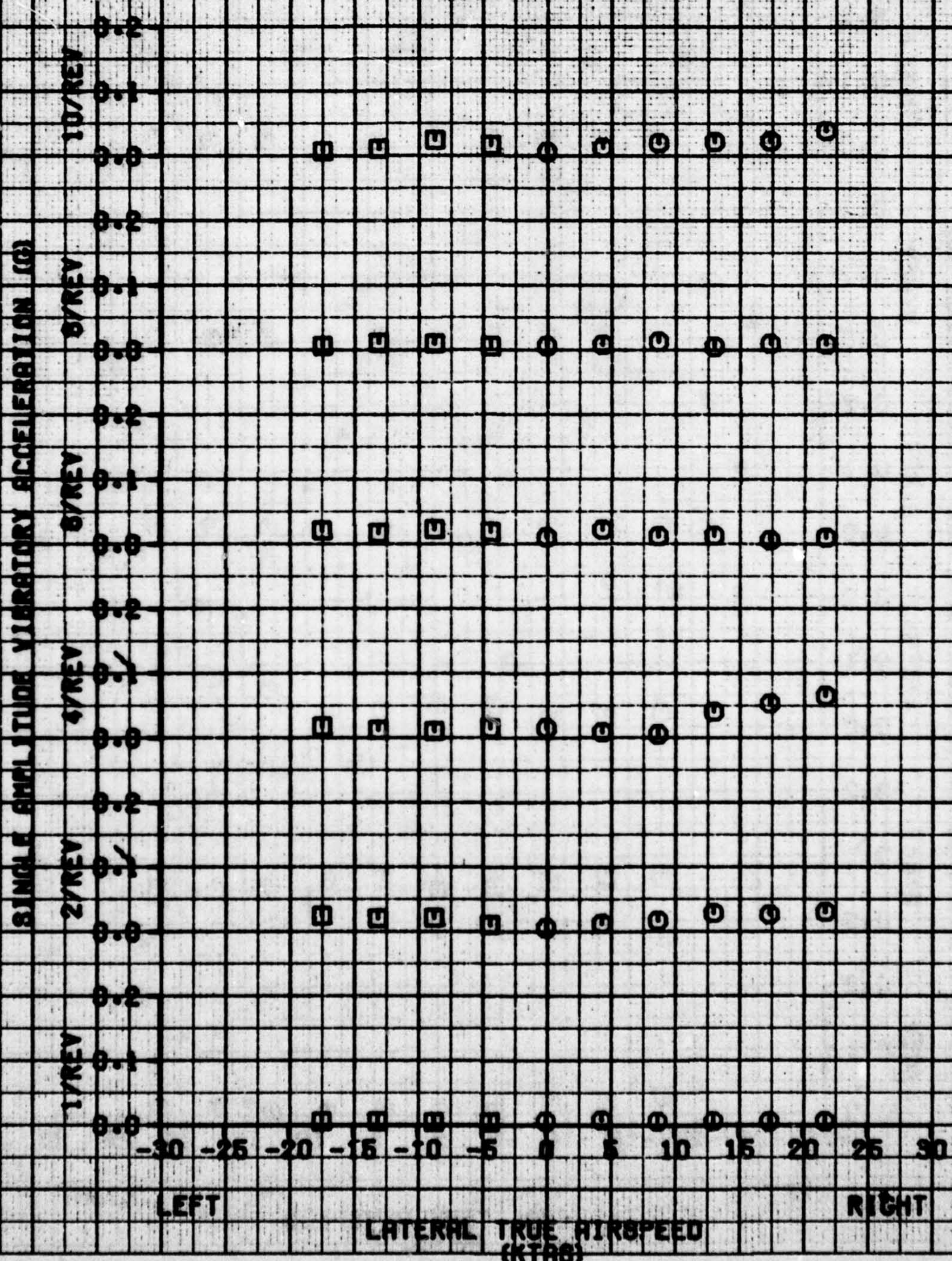


FIGURE 49
SIDEWARD FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CG VERTICAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENSITY ALTITUDE ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|
| 9540 | 195.2(MID) | 0.1(RT) | -3320 | -2 | 325 | 42.77 | 3 TOW | K-747 |

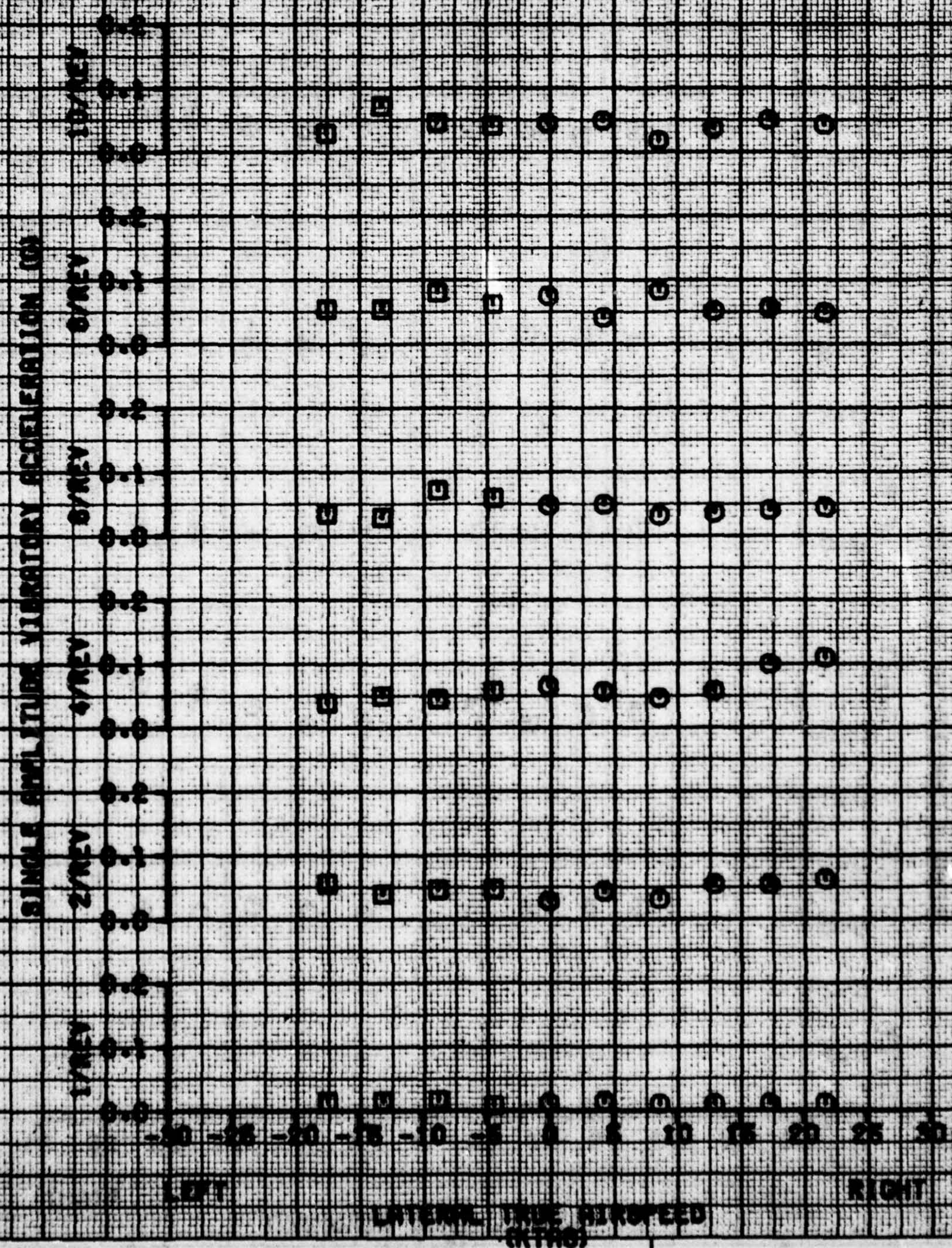


FIGURE 50
SIDEWARD FLIGHT VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CG LATERAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENSITY ALTITUDE ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ X $10^4$ | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|
| 9540 | 195.2(MID) | 0.1(RT) | -3320 | -2 | 325 | 42.77 | B TOW | K-747 |

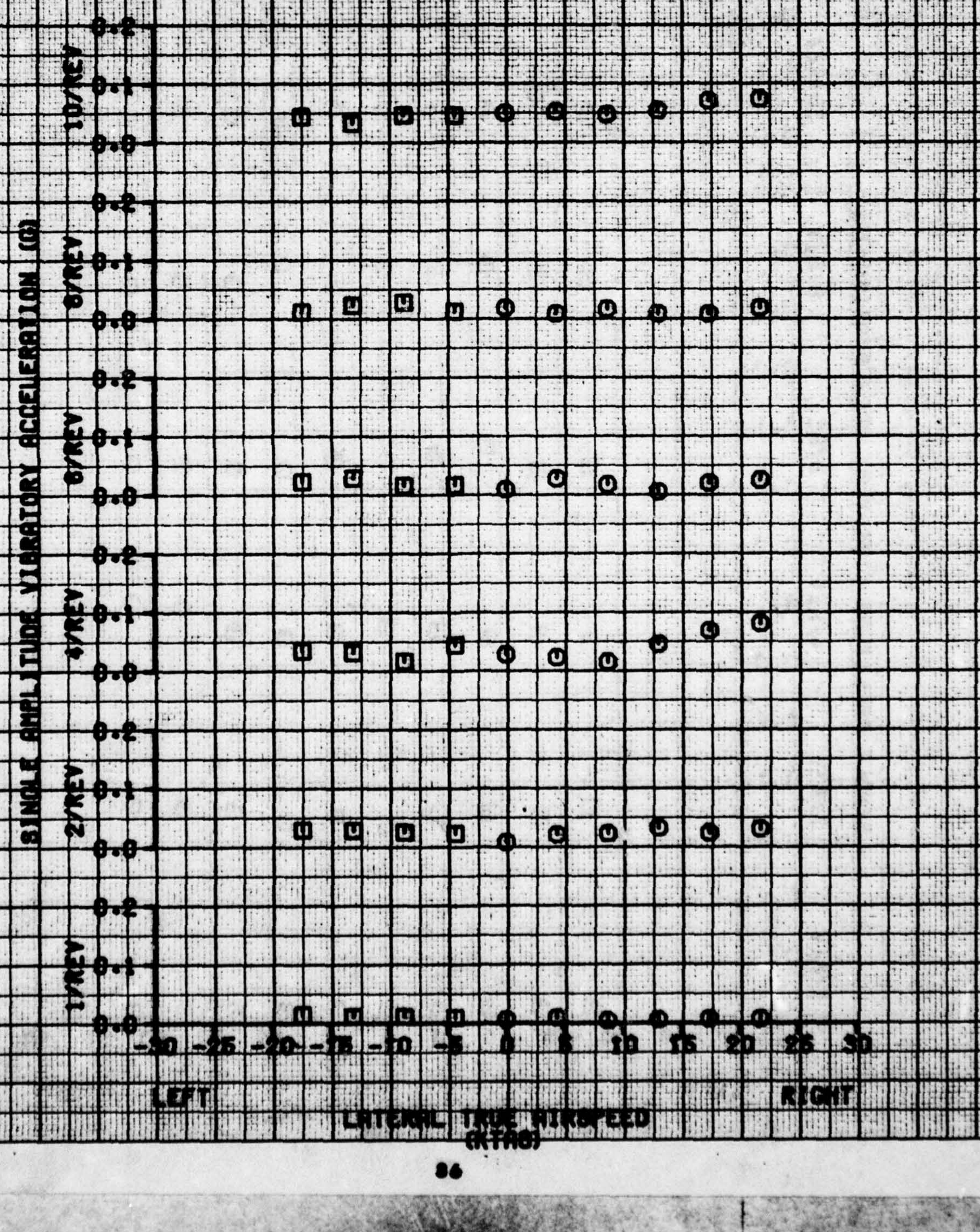


FIGURE 51
CLIMB VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT VERTICAL

| GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | AIRSPEED ~ KCAS | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| 9380 | 195.1(MID) | 0.1(RT) | 4780 | -4 | 325 | 53.36 | 57 | B TOW | K-747 |

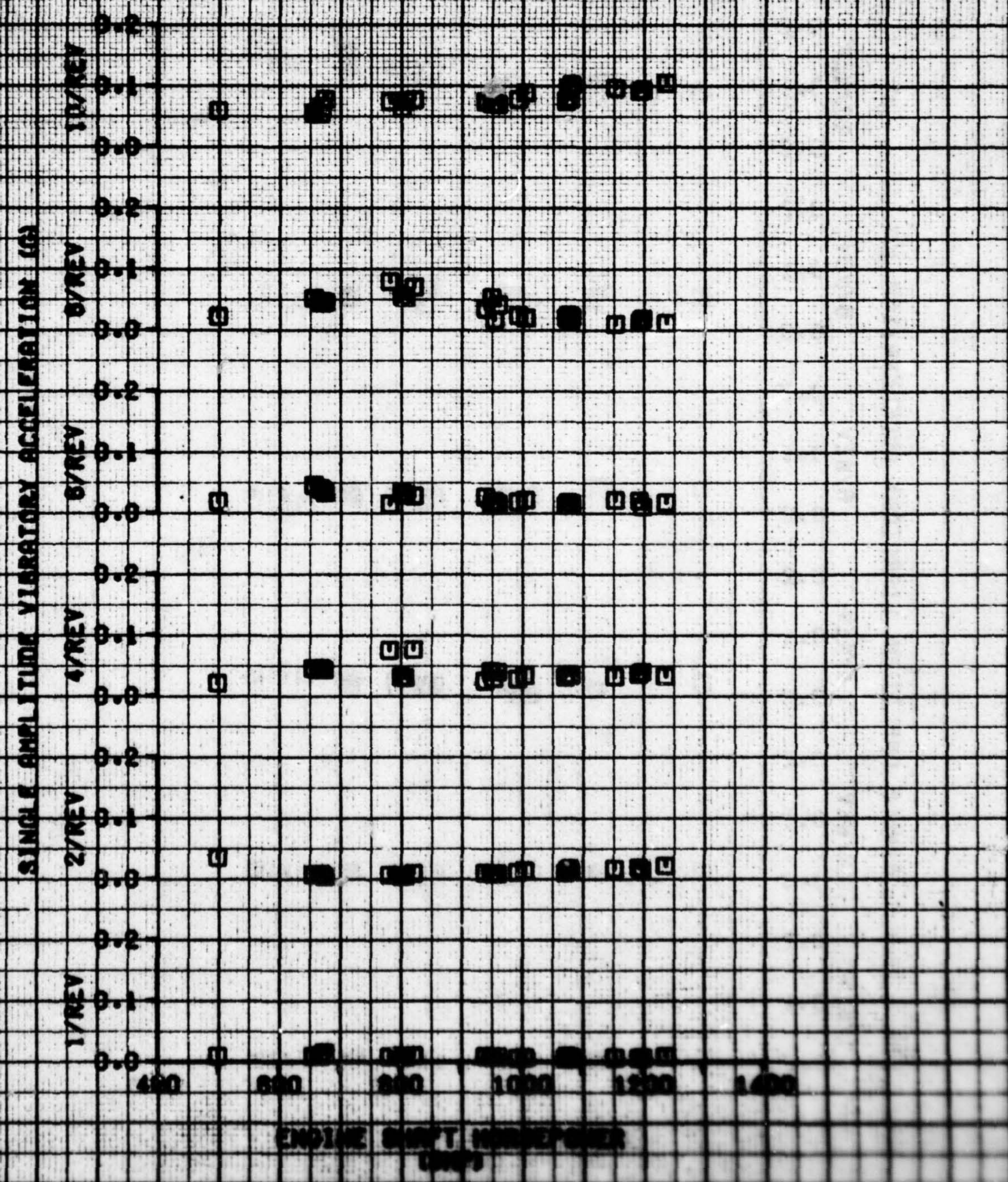


FIGURE 52
CLIMB VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT LATERAL

| GROSS WEIGHT ~ LB | CG LOCATION LONG FS | | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | AIRSPEED ~ KCAS | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9380 | 195 | 1(MID) | 0.1(RT) | 4780 | -4 | 325 | 53.36 | 57 | R TOW | K-747 |

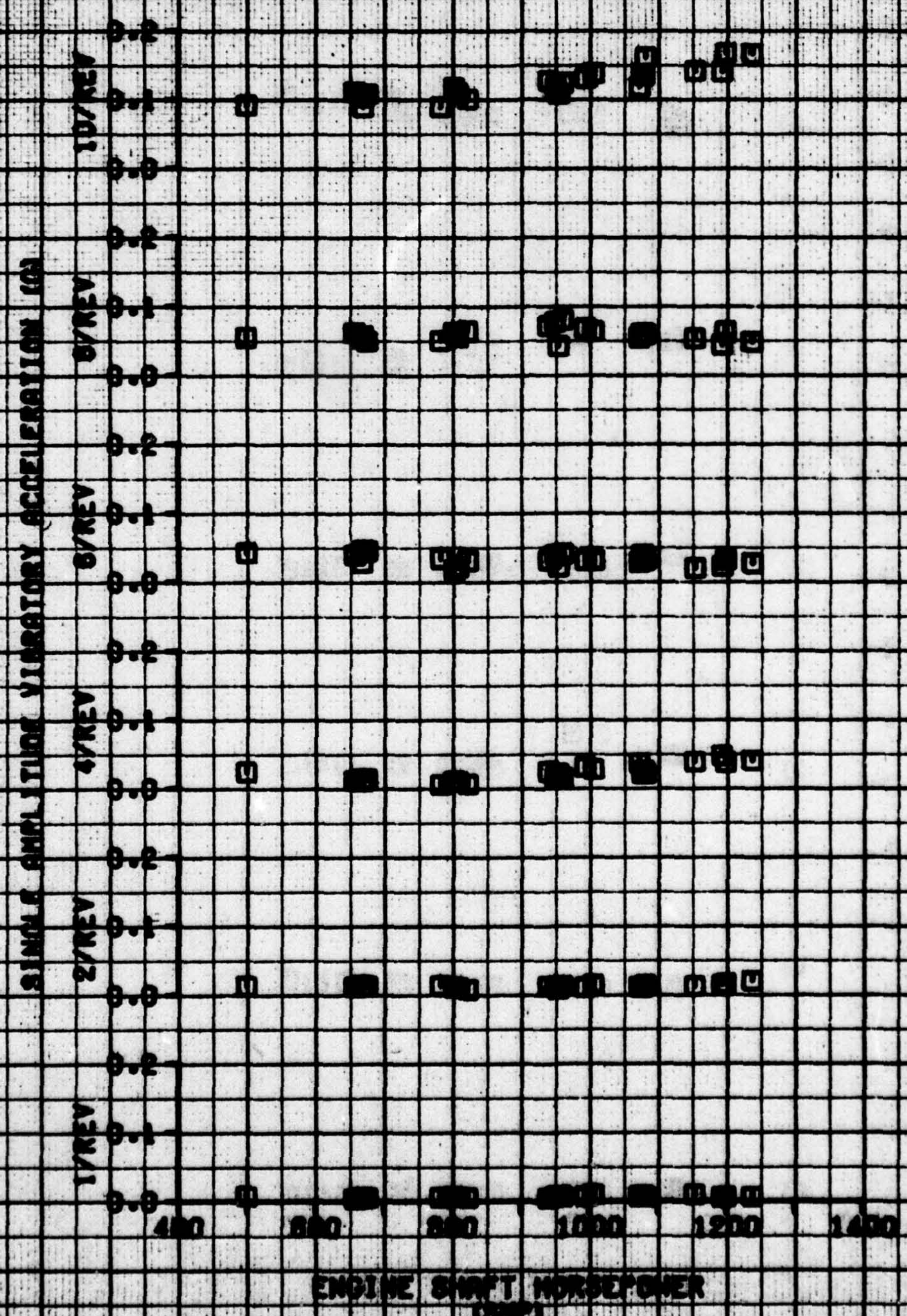


FIGURE 5[illegible]
[illegible] VIBRATION CHARACTERISTICS
[illegible]
PILOT LONGITUDINAL

| GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | AIRSPEED ~ KCAS | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| 9080 | 195.1(MID) | 0.1(RT) | 4780 | -4 | 325 | 53.36 | 57 | 3 TOW | K-747 |

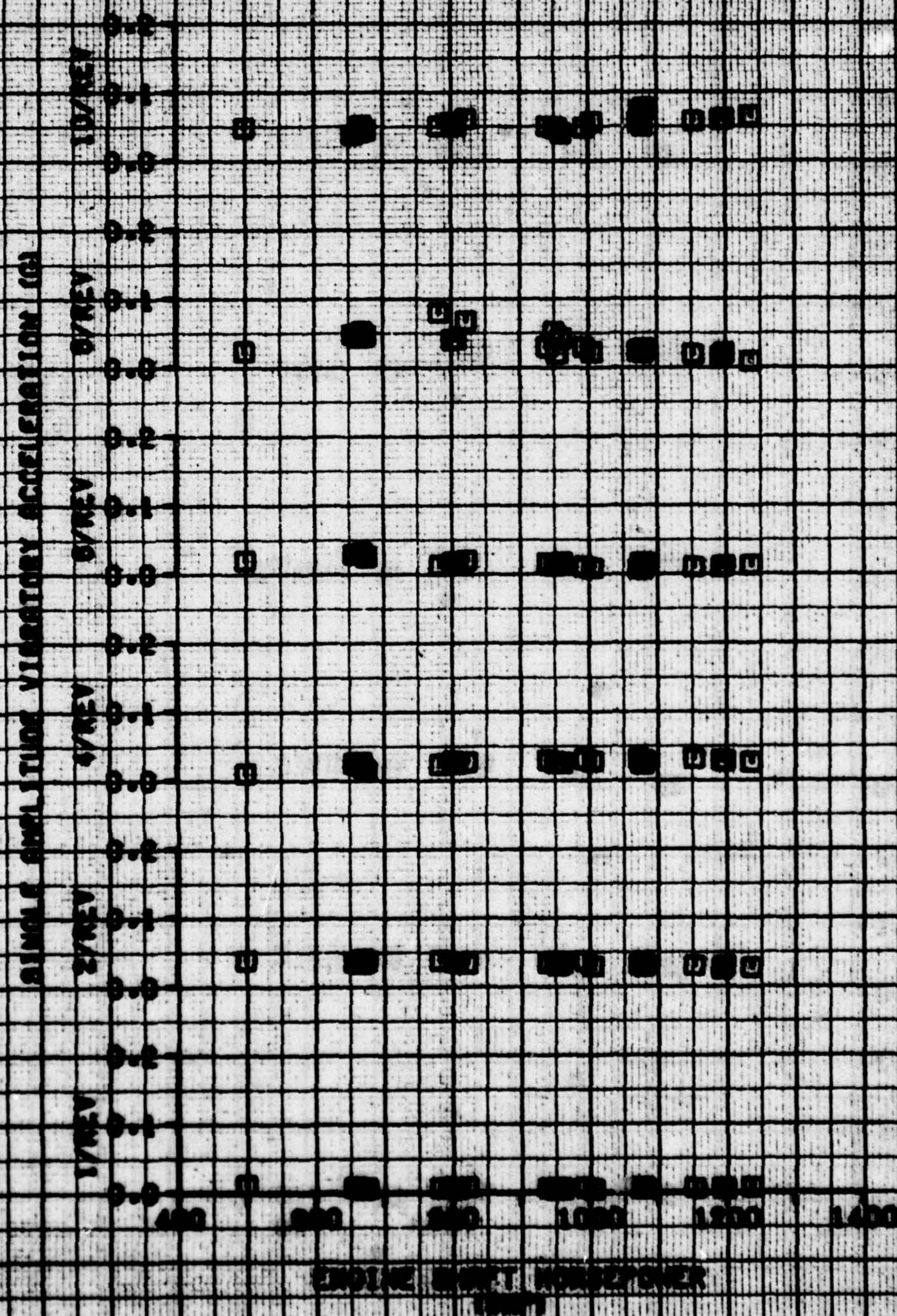


FIGURE 54
CLIMB VIBRATION CHARACTERISTICS
[illegible] USA S/N [illegible]
CO-PILOT VERTICAL

| GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | AIRSPEED ~ KCAS | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| 9880 | 195.1(MID) | 0.1(RT) | [illegible] | -4 | 325 | 53.36 | 57 | [illegible] | K-747 |

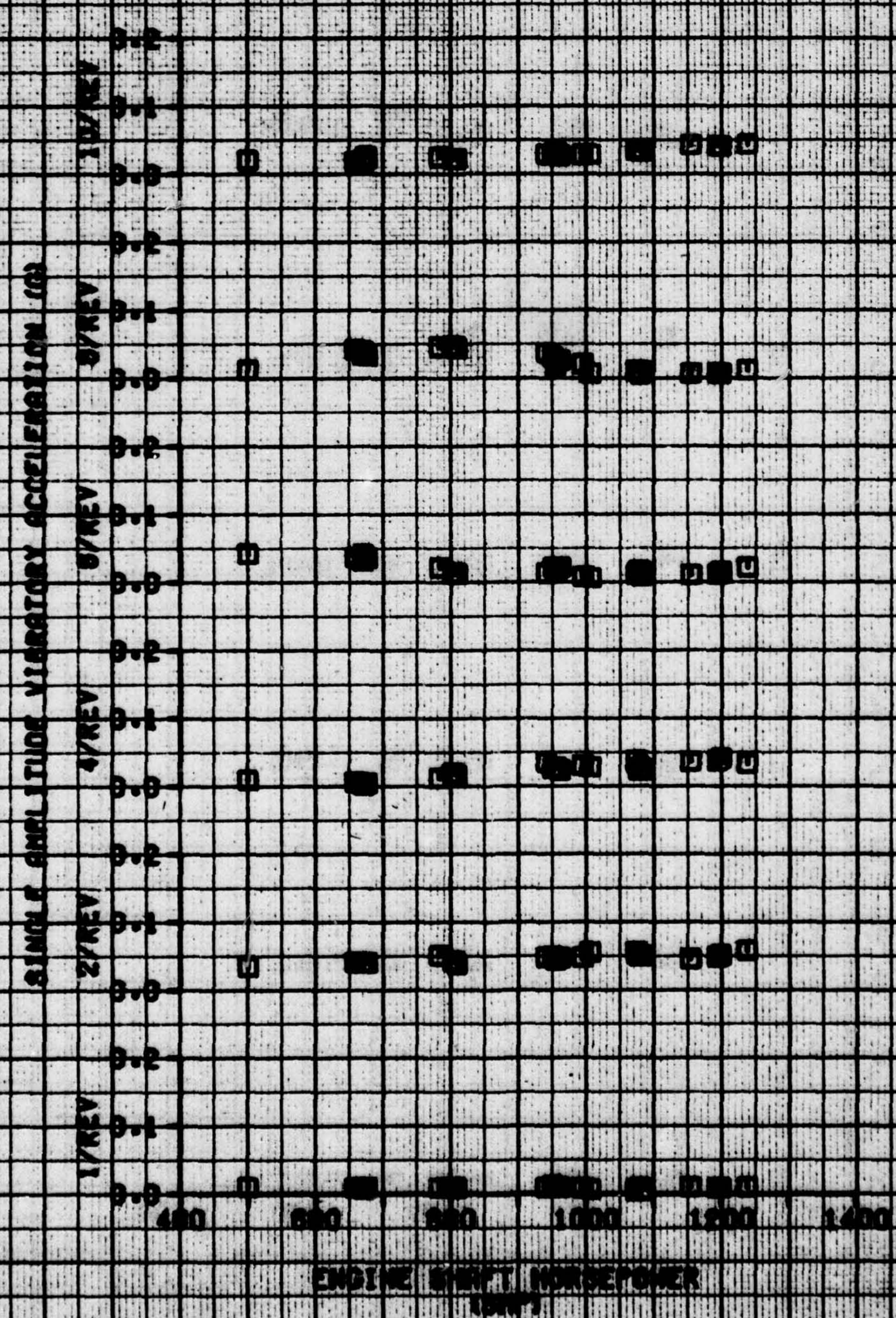


FIGURE 55
CLIMB VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT LATERAL

| GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | AIRSPEED ~ KCAS | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| 9080 | 195.1(MID) | 0.1(RT) | 4780 | -4 | 325 | 53.36 | 57 | 8 TOW | K-747 |

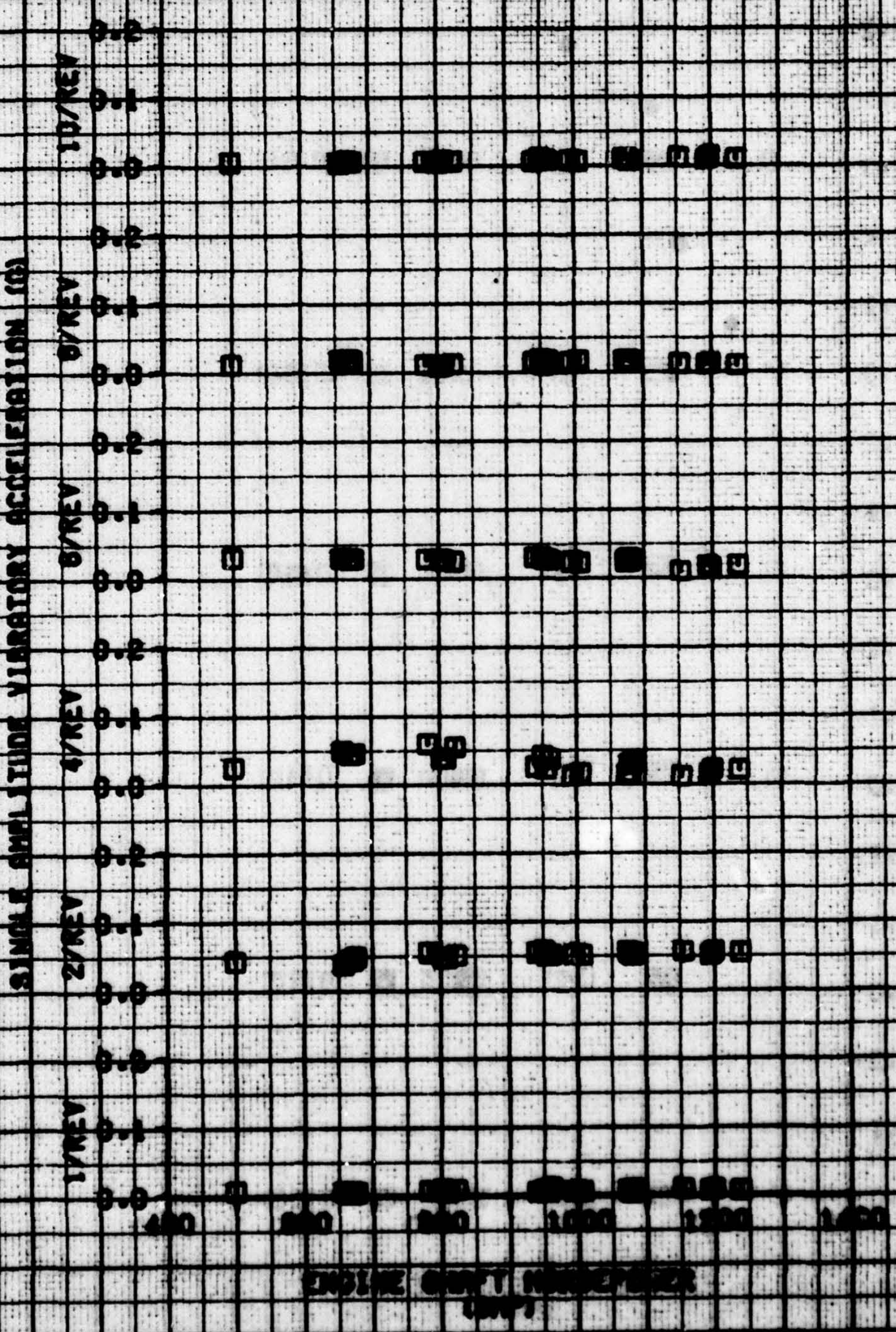


FIGURE 56
CLIMB VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT LONGITUDINAL

| GROSS WEIGHT ~ LB | CG LOCATION LONG FS | | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | AIRSPEED ~ KCAS | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9380 | 195 | 1(MID) | 0.1(RT) | 4780 | -4 | 325 | 53.36 | 57 | R.TOW | K-747 |

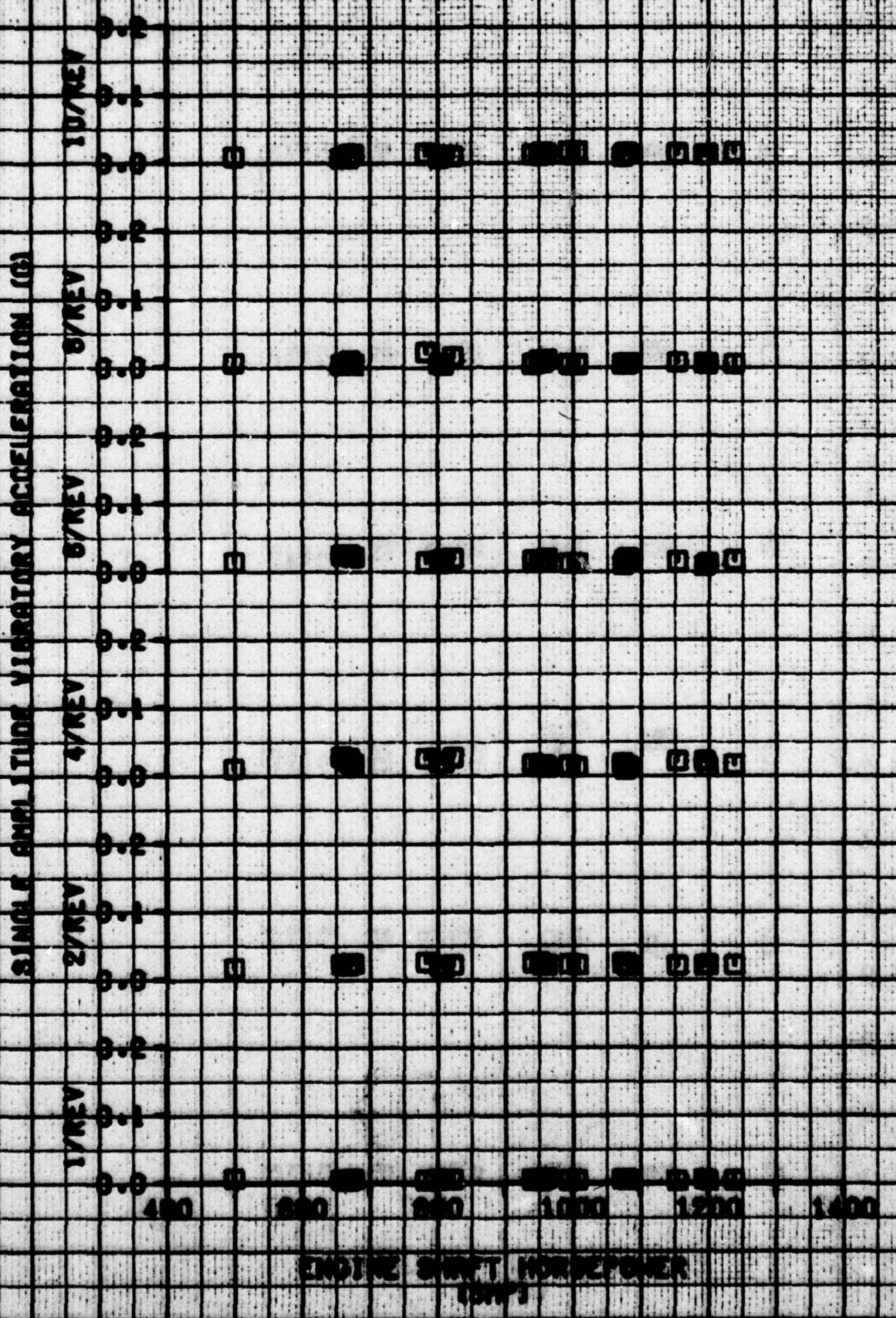


FIGURE 57
CLIMB VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CG VERTICAL

| GROSS WEIGHT ~ LB | CG LOCATION LONG FS | CG LOCATION LAT BL | DENSITY ALTITUDE ~ FEET | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | AIRSPEED ~ KCAS | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|
| 9080 | 195.1(MID) | 0.1(RT) | 4780 | 4 | 325 | 53.36 | 67 | B TOW | K-747 |

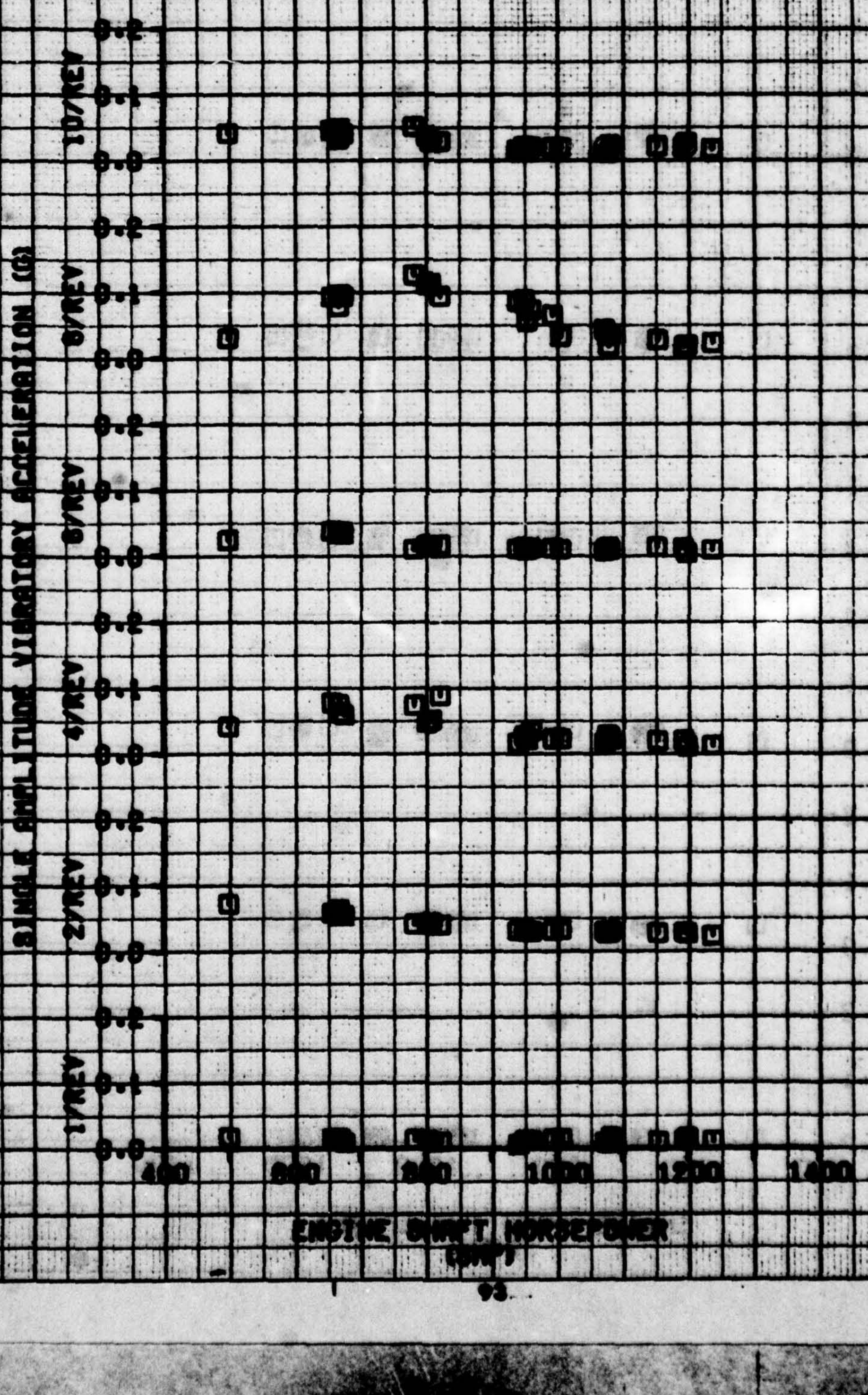


FIGURE 58
CLIMB VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CG LATERAL

| GROSS WEIGHT ~ LB | CG LOCATION LONG FS | | CG LOCATION LAT | DENSITY ALTITUDE ~ FEET | OAT ~°C | ROTOR SPEED ~RPM | $C_T$ X $10^4$ | AIRSPEED ~ KCAS | CONFIG | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9380 | 195 | 1(MID) | 0.1(RT) | 4780 | -4 | 325 | 53.36 | 57 | B TOW | K-747 |

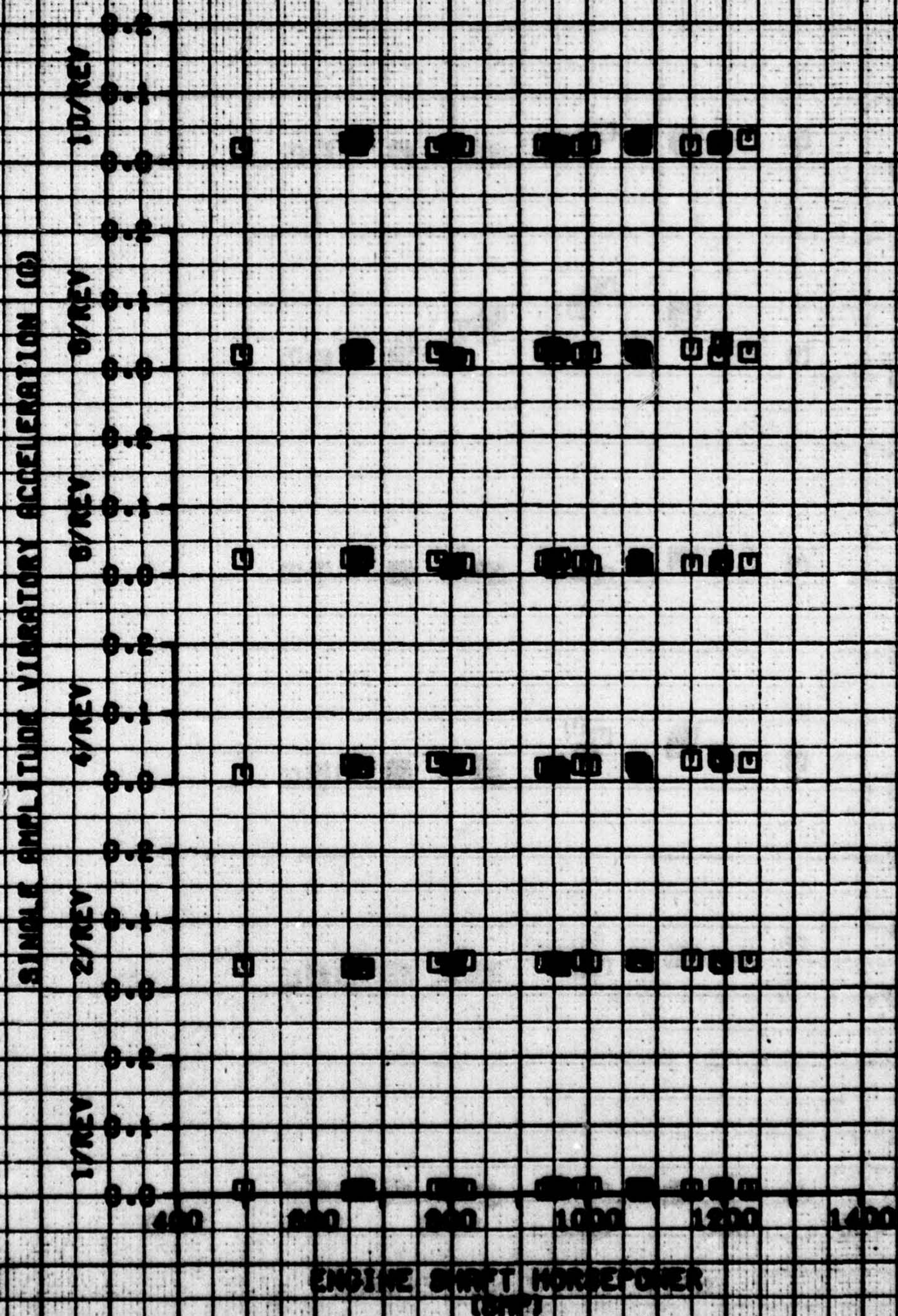


FIGURE 59
MANEUVERING VIBRATION CHARACTERISTICS
YAH-1R USA S/N [illegible]
[illegible] LONGITUDINAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | LAT BL | AVG DENS ALT ~FT | AVG OAT ~°C | ROTOR SPEED ~RPM | AVG $C_T$ $\times 10^4$ | TRIM A/S ~KCAS | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9800 | 201.1 (AFT) | 0.1 (RT) | 5360 | -4 | 325 | 57.25 | 57 | HOG | STEADY TURNS | K-747 |

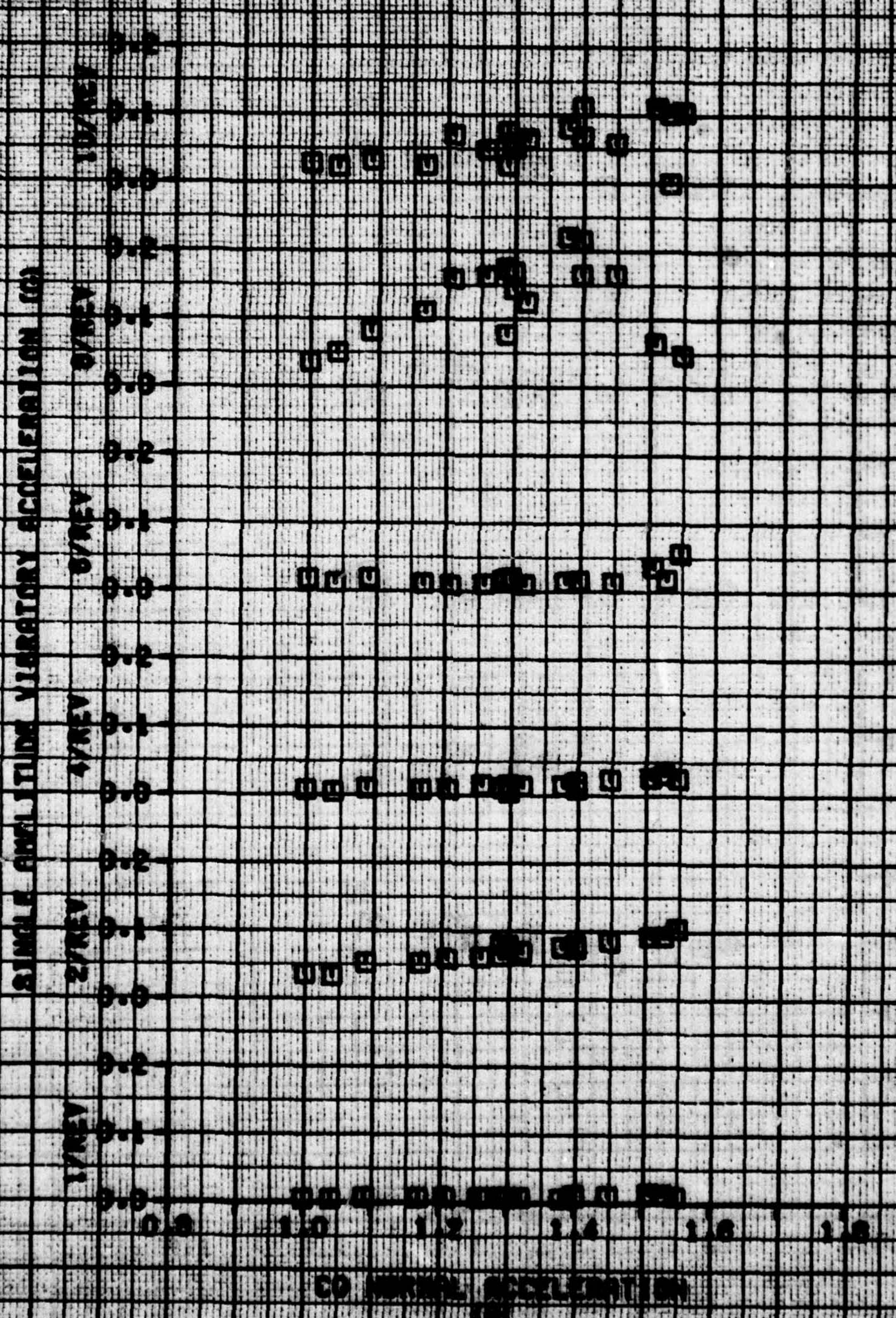


FIGURE 60
MANEUVERING VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT VERTICAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | LAT BL | AVG DENS ALT ~FT | AVG OAT ~°C | ROTOR SPEED ~RPM | AVG $C_T$ X $10^4$ | TRIM A/S ~KCAS | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9880 | 201.1(AFT) | 0.1(RT) | 5380 | -4 | 325 | 57.25 | 57 | HOG | STEADY TURNS | K-747 |

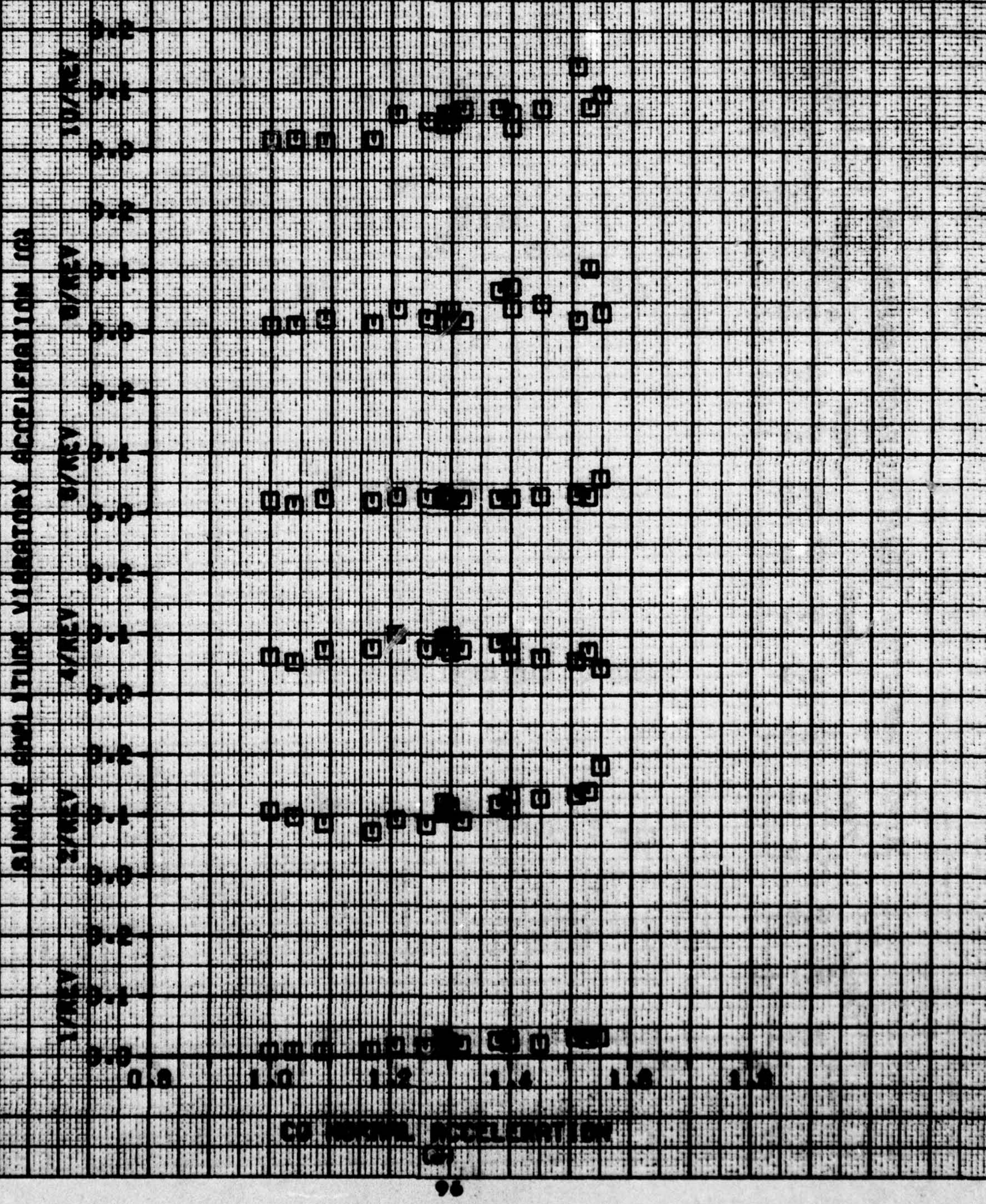


FIGURE 61
MANEUVERING VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
COPILOT LATERAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | | AVG CG LOCATION LAT BL | AVG DENS ALT ~FT | AVG OAT ~°C | ROTOR SPEED ~RPM | AVG $C_T$ X $10^4$ | TRIM A/S ~KCAS | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9880 | 201 | 1(AFT) | 0.1(RT) | 5380 | -4 | 325 | 57.25 | 57 | HOG | STEADY TURNS | K-747 |

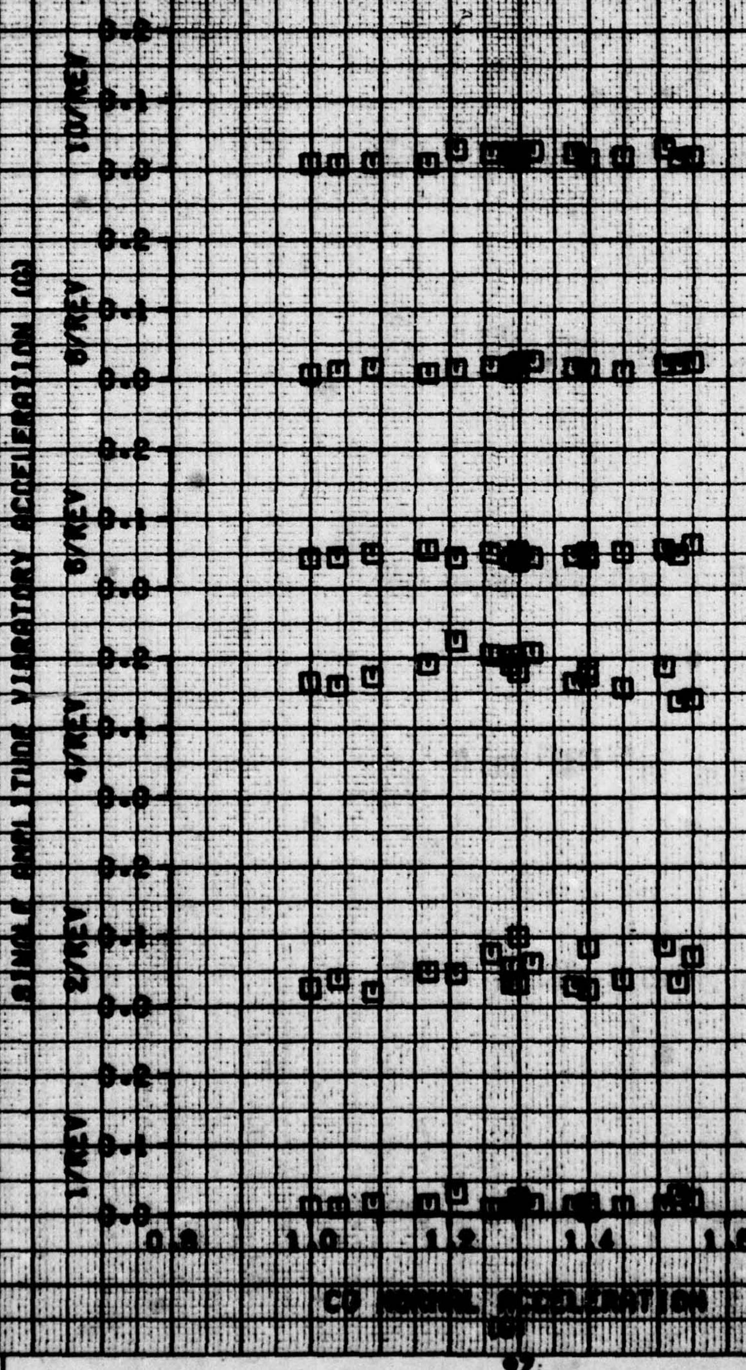


FIGURE 62
MANEUVERING VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT LONGITUDINAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENS ALT ~FT | AVG OAT ~°C | ROTOR SPEED ~RPM | AVG $C_T$ $\times 10^4$ | TRIM A/S ~KCAS | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9880 | 201.1(AFT) | 0.1(RT) | 5380 | -4 | 325 | 57.25 | 57 | HOG | STEADY TURNS | K-747 |

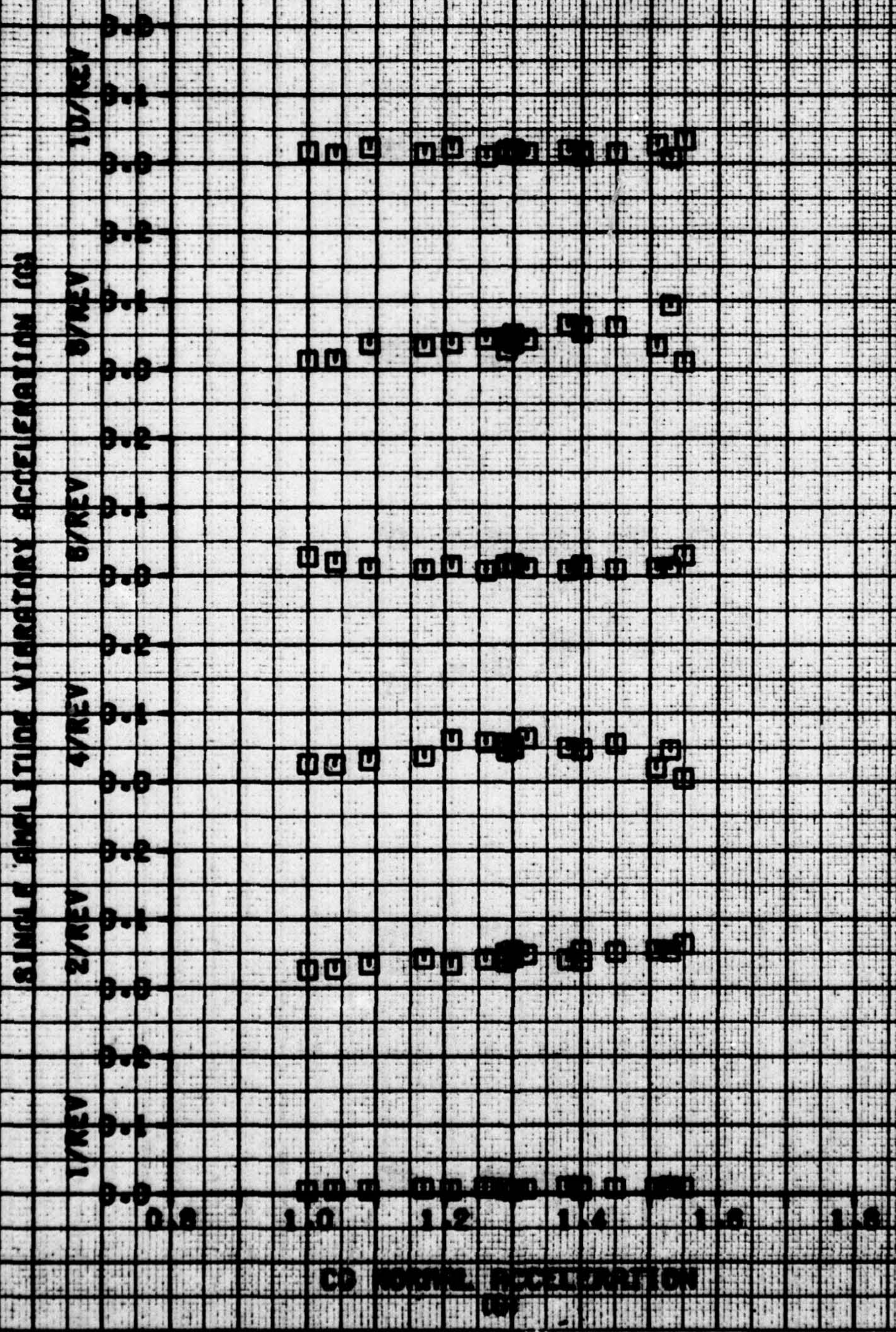


FIGURE 63
MANEUVERING VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CG LATERAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENS ALT ~FT | AVG OAT ~°C | ROTOR SPEED ~RPM | AVG $C_T$ X $10^4$ | TRIM A/S ~KCAS | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9380 | 201.1(AFT) | 0.1(RT) | 5380 | -4 | 325 | 57.25 | 57 | HOG | STEADY TURNS | K-747 |

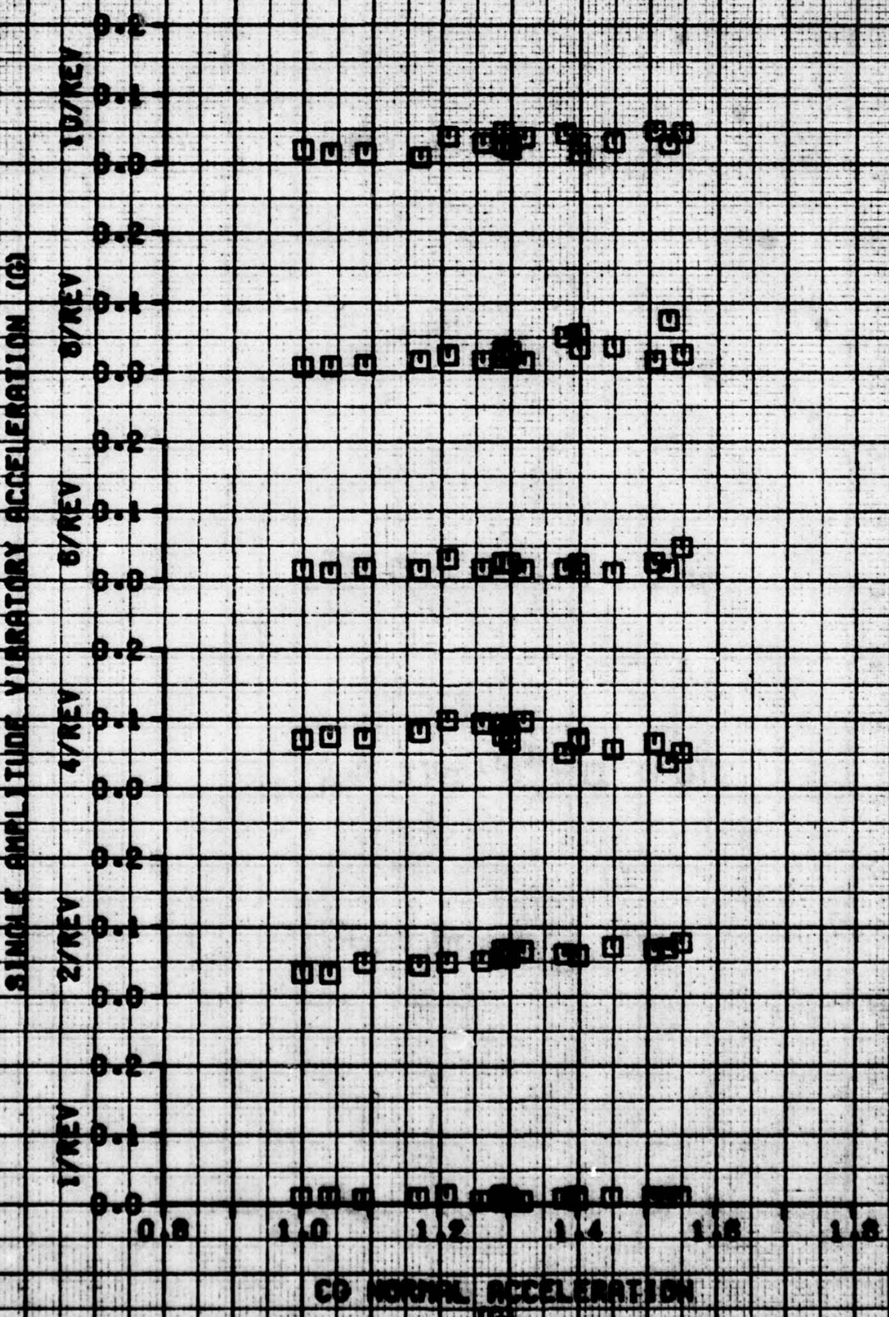


FIGURE 64
MANEUVERING VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CG LONGITUDINAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENS ALT ~FT | AVG OAT ~°C | ROTOR SPEED ~RPM | AVG $C_T$ $\times 10^4$ | TRIM A/S ~KCAS | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9880 | 201.1(AFT) | 0.1(RT) | 5380 | -4 | 325 | 57.25 | 57 | HOG | STEADY TURNS | K-747 |

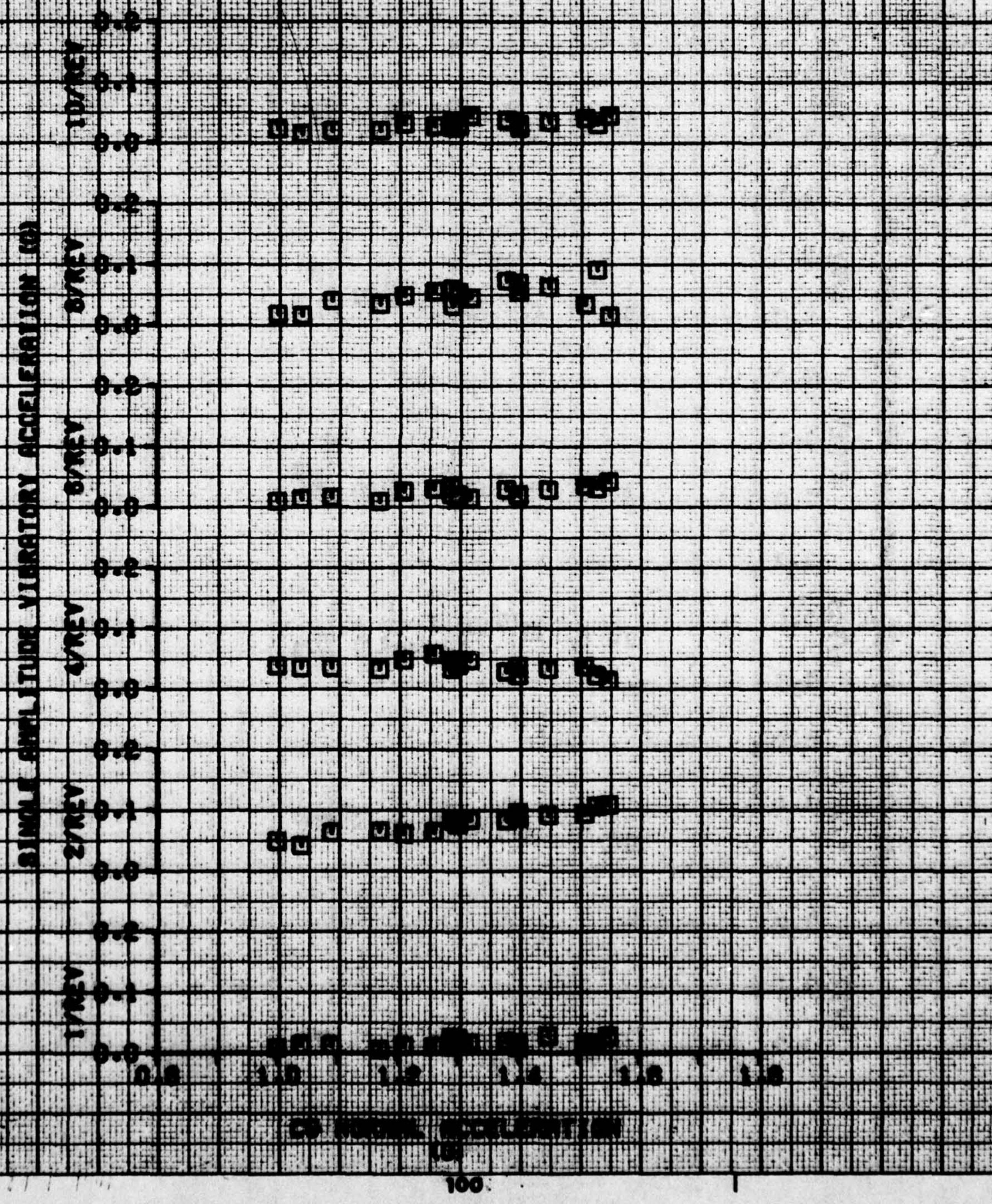


FIGURE 65
MANEUVERING VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
PILOT LONGITUDINAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENS ALT ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ X $10^4$ | TRIM A/S ~KCAS | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9600 | 201.0(AFT) | 0.1(RT) | 5550 | -2 | 326 | 55.92 | 117 | HOG | STEADY TURN | K-747 |

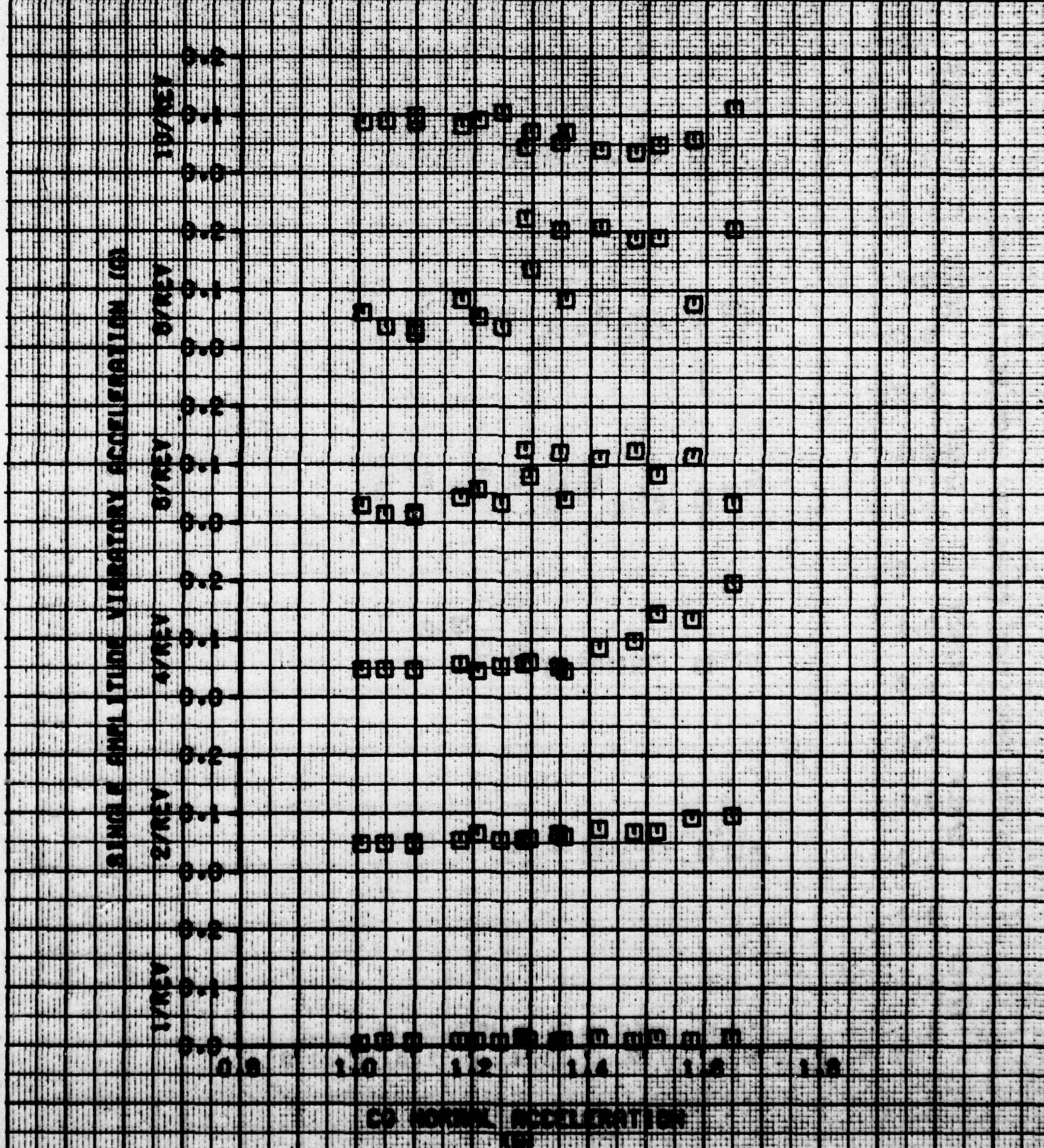
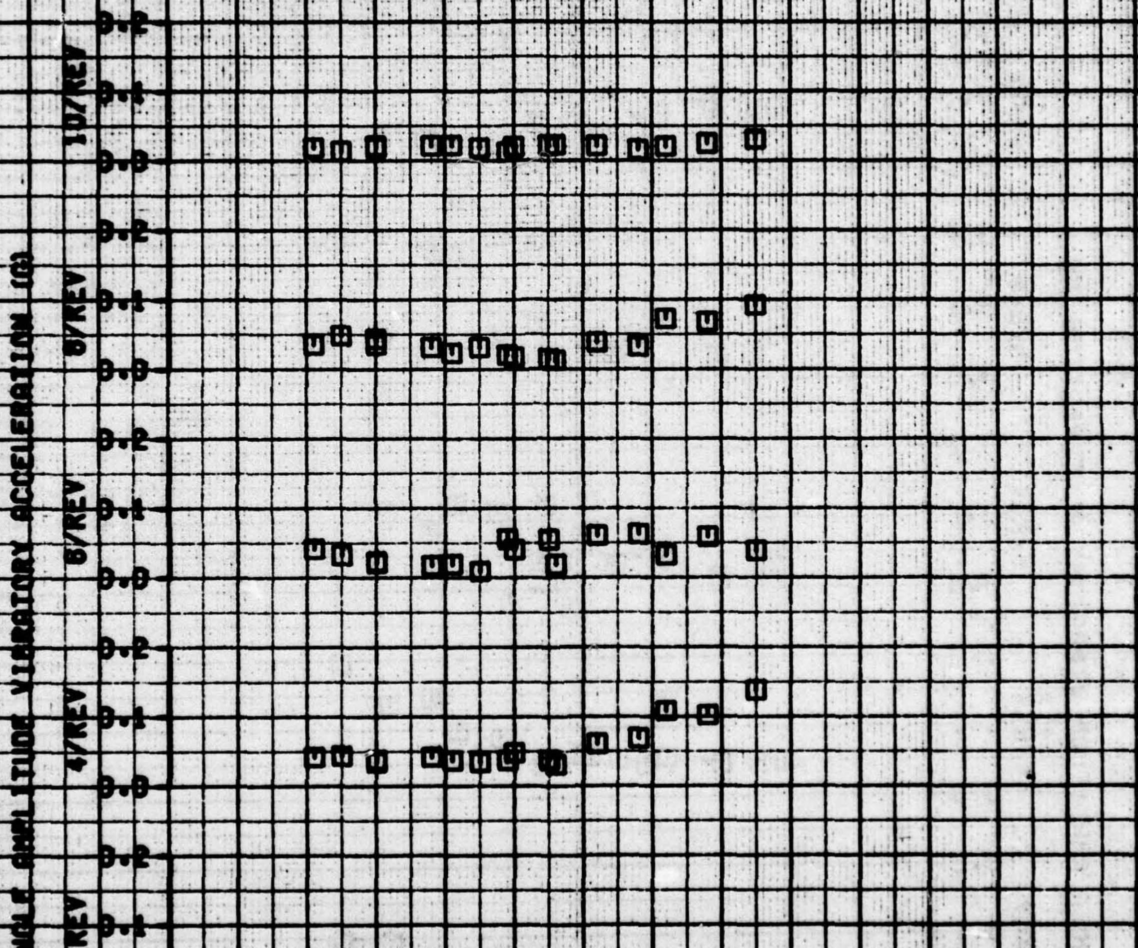


FIGURE 66
MANEUVERING VIBRATION CHARACTERISTICS
YAH-1R USA S/N 70-15936
CO-PILOT LONGITUDINAL

| AVG GROSS WEIGHT ~LB | AVG CG LOCATION LONG FS | AVG CG LOCATION LAT BL | AVG DENS ALT ~FT | AVG OAT ~°C | AVG ROTOR SPEED ~RPM | AVG $C_T$ X $10^4$ | TRIM A/S ~KCAS | CONFIG | FLT COND | ROTOR |
|---|---|---|---|---|---|---|---|---|---|---|
| 9600 | 201.0(AFT) | 0.1(RT) | 5560 | -2 | 326 | 55.92 | 117 | HOG | STEADY TURN | K-747 |



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